PRICE DYNAMICS IN THE U.S. SHRIMP MARKET

By

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To Mom and Dad

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Previous research regarding the dynamics of price determination in the domestic shrimp market is lacking. Understanding the mechanism of price determination in a dynamic setting is imperative to formulating effective policy and assessing price impacts at each market level. This study examines the monthly and quarterly price determination process for raw-headless shrimp of the 31-40 and 21-25 size classes.

The presence of Granger causality was assessed between adjacent market levels by using the Haugh-Pierce, Sims, and Granger tests. Distributed lag structures were identified between adjacent market levels that embody the empirically determined lead/lag relationship. Price dependent demands at the retail, wholesale, and ex-vessel market levels were estimated. Expressions for marketing margins were derived.

Monthly prices for both size classes in general exhibited unidirectional causality from ex-vessel to wholesale to retail price. Unidirectional causality did not characterize the ex-vessel/wholesale relationship for the 21-25 size class. Quarterly prices for both size classes were interdependent among market

levels, with no unidirectional causality evident. The prices for the larger size class shrimp adjusted slower to changes in the lagged causal price than did the prices for the smaller shrimp.

Wholesale and ex-vessel prices were found to be more closely related than retail and wholesale prices for both size classes. Monthly prices were dependent on current and lagged causal price, however, lagged causal price was not an important determinant of quarterly price. Price response between market levels for both size classes was found to be symmetric.

Income, prices of competing meat products, and imports of other size classes of shrimp were not important determinants of price for either size class. Changes in total retail supply had a relative larger impact on the price for the 21-25 size class, while beginning stocks, own and other size landings and imports of own-size shrimp had a larger negative impact on price for the 31-40 size class than for the 21-25 size class. Changes in beginning stocks and landings and imports of own-size shrimp were the most import determinants of price at each market level. Changes in the marketing cost index had a larger impact on prices for the 21-25 size class than for the 31-40 size class. Marketing margins were negatively related to changes in quantity variables and positively related to changes in marketing costs. Income and the price index for competing meat products were not important determinants of marketing margins.

Prices for the 31-40 size class are more affected by quantity changes, particularly at the retail level. Thus, policy measures which alter the quantity or size distribution of shrimp through import quotas, tariffs, or seasonal restrictions, will have a greater price impact on the smaller shrimp. Increased supplies of maricultural shrimp will have a greater relative price impact on the 31-40 size class.

CHAPTER I
INTRODUCTION

Management of the domestic shrimp fishery in the United States has proven to be a considerable task. The goal of effective implementation of policy has resulted in the organization of a complex management structure and the allocation of substantial sums of research dollars to be directed toward current research needs.

The passage of the Magnuson Fishery Conservation Management Act PL 94-265 (MFCMA) in 1976 dictated an increased need and provided further direction for the investigation of mechanisms and functions of seafood markets. A number of studies have been carried out concerning the various species of fish and shellfish in the seafood industry. The majority of these studies, when touching on economic issues, have rarely extended past the dockside market (Schuler, 1983). This appears to be due to a major emphasis being placed on management of physical resources. A few species, such as shrimp, have garnered an increasing level of research funds to be utilized toward a more complete analysis of the marketing system—from producer to consumer.

The impetus for this expression of increased need of control over the fishery and its market system has been that the shrimp industry has been growing in volume, value, and complexity. As the standard of living has increased in the U.S., the demand for luxury goods, such as shrimp, has increased. The consumption of fish and shellfish products has increased steadily over the past two decades (U.S. Dept. of

Commerce(b), 1983). The Food and Agricultural Organization of the United Nations predicts fish and shellfish consumption will probably increase through 1990 at a rate of growth greater than that for pork, beef, vegetables, cereals, and milk (Office of Technology Assessment, 1977). In particular, per capita consumption of shrimp products (edible meat weight) increased almost 50 percent from 1.08 pounds in 1960 to 1.52 pounds in 1982 (U.S. Dept. of Commerce(b), 1983). As a result of increased demand, the value of shrimp products has exhibited a commensurate increase. The increased complexity of the industry has manifested itself in terms of increased awareness of biological and producer (effort) relationships, an increasingly more intricate domestic market system, and growing interdependence with world markets. For the formulation and implementation of effective fishery management and, especially, trade policy, the understanding of market functions and dynamics must keep pace with growth and change in the market system.

In accordance with this need, some research efforts have been directed toward understanding and detailing the U.S. shrimp market system. The National Marine Fisheries Service has maintained a base of production and market data on the shrimp industry. Significant gains in understanding the shrimp industry have resulted. However, this study proposes that there exists a significant absence of knowledge in the area of price formulation; particularly in terms of price dynamics and the behavior of price margins throughout the different levels of the market system. Even less effort has been directed toward examining these relationships on a product form and size basis for shrimp as the product moves through the marketing system. In addition, the direction of price determination in the market has never been formally tested.

This has relegated the specification of the nature of the pricing system in most empirical studies, in terms of being either simultaneous or recursive, to simply a matter of precedence or guesswork. The lack of understanding in these causal relationships has been borne out by publication of contradictory model formulations and empirical results.

The marketing system for shrimp is an intricate mechanism. Before the finished product reaches the consumer at the restaurant, fresh fish market, or retail grocery store, the shrimp product may pass through various combinations of handlers. The path taken is related to the origin, form, and destination of the shrimp product. With the primary supply at the producer (or importer) level and primary demand at the consumer level, a maze of derived demand and supply relationships exist, each generating respective prices. These prices are a function of the market for marketing services and imputs employed at each stage of processing and determine the gross margin which exists between the respective market levels. The responsiveness of these prices to exogenous and endogenous change in the market place is directly related to how quickly and at what magnitude changes in profit and costs are passed between the various market levels. Structural differences between levels in the market system and informational advantages from one level to another may play a major role in the efficient transmission of prices between market levels. Understanding how the market levels interface and how efficiently the respective price linkages adjust, in terms of speed and magnitude, is of utmost importance if policy is to reach its goal of formulating effective measures in the market system. Participants throughout the market system will benefit through further understanding of the price linkage system. Knowledge of how the margins

adjust between market levels will allow each level to observe and react to market signals more efficiently. This will be especially true for non-adjacent market levels.

Increased understanding of the efficiency and dynamics of the U.S. shrimp market system should provide for a greater chance of achieving the long-run goals established by the MFCMA. The possibility of formulating effective policy and the realization of benefits to all levels of the market, from consumer to producer, would surely be increased if the aspects of basic market functions are more thoroughly understood. Such understanding of the dynamic properties of price determination would be invaluable to achieving more efficient fishery management policy formulation as dictated by the MFCMA and motivated by current economic problems in the industry.

Overview of Industry

Resource and Harvesting

The U.S. shrimp industry is the single most valuable component of the nation's fishing industry, when measured in terms of dockside value of commercial landings. There are four major shrimp producing areas in the U.S.: Gulf of Mexico, Pacific Northwest, South Atlantic, and New England, in order of landings volume. The Gulf reported 74.0 percent of total commercial landings in 1982 (U.S. Dept. of Commerce(b), 1983). The primary species sought in the Gulf and South Atlantic are warm water estuarine-dependent species of the family Penaeidae, specifically, white shrimp (*Penaeus setiferus*), brown shrimp (*P. aztecus*), and pink shrimp (*P. duorarum*). The major regions of production for brown, white, and pink shrimp in order of importance are Texas, Louisiana, and Florida,

respectively. The major species in the Pacific fishery are cold water, non-estuarine-dependent shrimp of the family Pandalidae. These shrimp are typically smaller than the Gulf species and are marketed differently (U.S. International Trade Commission, 1976). The major production periods for Gulf shrimp are June and July for browns and September and October for whites and pinks.

The primary method for taking shrimp is a twin otter trawl which is pulled along the bottom in up to 40 fathoms of water. A smaller percentage of the catch is taken by deep water trawls in the Pacific and stationary butterfly nets which are fished at the mouth of the estuaries in Louisiana as shrimp move from the estuaries to the Gulf. Hu (1983) estimates there are approximately 27,000 people who depend on harvesting shrimp on a full or part time basis in the U.S. The majority of these are in the Gulf of Mexico where fleet size was estimated to be 10,060 boats and vessels in 1980 (Prochaska and Cato, 1981). Boats are defined as craft less than five net tons and vessels are craft five net tons and over. The number of vessels increased from 2,600 in 1961 to 4,585 in 1980, an increase of 76 percent. The number of vessels increased 24 percent from 1976 to 1980. The number of boats increased 2,987 in 1961 to 5,475 in 1980, an increase of 52 percent. The number of boats increased 19 percent from 1976 to 1980.

Since 1980, the extended jurisdiction by Mexico over coastal waters out to 200 miles from its own coastline has displaced a number of U.S. craft from the rich Campeche grounds, a traditional fishing area for U.S. shrimpers. These craft have moved from Mexican waters to U.S. coastal waters, which extend 200 miles from the coastline since the enactment of extended jurisdiction by the U.S. in 1976. This area,

which extends from the state water boundary out to 200 miles from shore, is known as the Fishery Conservation Zone (FCZ). This displacement of craft from the Campeche grounds to the FCZ is believed to have had a significant effect on the domestic industry (Fishing Gazette, 1981). Fleets that depended on the revenues generated by fishing the Campeche grounds (estimated at $35 million in 1979) have had to begin fishing operations in the FCZ. An estimated 600 shrimp vessels were displaced by the Mexico closure. As the craft entered the FCZ fishery, landings per craft trended downward, while total landings exhibited no apparent trend (U.S. Dept. of Commerce(b), various years). Competition among domestic producers has increased as relatively stable domestic stocks within the FCZ are being fished by an increasing number of vessels. In general, as the number of vessels and boats has increased, average landings, catch per unit of effort, and gross revenues per craft have been declining. Environmental conditions appear to have a greater impact on total catch than does effort, but effort appears more significant with respect to catch per unit effort.

General Industry Trends

Total commercial domestic shrimp landings in the U.S. have been relatively constant since the early 1950's. The fishery in the U.S. can be considered a mature fishery. A slight upward trend existed from 1961 to 1970 (average annual increase of 5.8 percent). Between 1970 and 1982, there appeared to be no apparent trend (1.3 average annual percent change); however, considerable year-to-year fluctuation existed. The total commercial landings in the U.S. in 1982 were 175.9 million pounds heads-off. This was a significant decrease from 218.0 million pounds in

1981 and represented only a 19.0 percent increase in landings since 1960 (U.S. Dept. of Commerce(d), various years). The record year was 1977 when a domestic catch of 288 million pounds was reported.

While U.S. landings have apparently reached a plateau, alluding to the attainment of maximum sustainable yield in the fishery resource, U.S. consumption has surpassed U.S. production. Consumption of all forms of shrimp products in 1982 was 399.6 million pounds and 1.52 pounds edible meat weight per capita. Both total and per capita consumption trended up between 1960 and 1970, with a plateau being reached and maintained during the 1970's. A maximum was reached in 1977 at 1.56 pounds per capita. This can be contrasted to per capita consumption of all fishery products in the U.S. which had a continual upward trend from 10.3 pounds in 1960 to 12.3 pounds in 1982 (U.S. Dept. of Commerce(b), 1983).

Consumption of individual shrimp product forms has been changing. In 1960, raw-headless shrimp represented the largest share of total consumption of the four major forms of shrimp products at 47.8 percent with peeled, breaded, and canned shrimp representing 25.2, 8.0, and 9.0 percent of total consumption, respectively (Hu, 1983). By 1980, this ordering had changed with peeled/deveined, raw-headless, breaded, and canned capturing 46.1, 35.1, 12.1, and 6.7 percent of total consumption, respectively. On a per capita consumption basis, raw-headless and peeled/deveined product forms demonstrated the more noticeable increases during the last two decades. Consumption of raw-headless and peeled/deveined shrimp increased from .69 and .24 pounds, respectively, in 1960 to .92 and .60 pounds in 1980. During this period, raw-headless shrimp remained the most important product form on a per capita basis.

However, peeled/deveined shrimp overtook breaded shrimp as the second most important product form consumed. Breaded and canned forms remained relatively constant on a per capita basis over this time period.

With domestic landings falling short of consumption, imports have played a critical role in maintaining supply in the shrimp industry for many years. Imports have exceeded domestic landings since 1961, except for the years 1971, 1977, and 1978. Between 1960 and 1982, imports more than doubled. The major exporters of shrimp to the U.S. are Mexico, Ecuador, Panama, and India, in order of volume (Suazo, 1983). As with domestic landings, imports apparently reached a plateau in 1970, with an average annual increase of only 1.0 percent between 1970 and 1981 (U.S. Dept. of Commerce(d), various years). The total volume of imports increased from 122.5 million pounds in 1960 to 247.2 million pounds in 1970, an average annual percentage increase of 7.5 percent. Imports increased to 320 million pounds in 1982, an average annual percentage increase from 1970 of only 3.1 percent. The total 1982 imports, however, represented a 24 percent increase from 1981. Preliminary estimates put the level of 1983 imports even higher at 421 million pounds. Ecuador has become increasingly important in the import market due to that country's increased production of maricultured shrimp. Thus, imports are increasing, possibly due in large part to shrimp produced in non-traditional fashion. The U.S. has long been the major market for world shrimp supplies, with Japan running second. However, Japan's use of world shrimp products exceeded that of the U.S. in 1979 and 1981, increasing the degree of competition for stable world supplies.

Imports have been suggested to have a depressant effect on producer prices. As the domestic market comes to rely more heavily on imports,

producers have become increasingly more concerned about the price effect and substitutability relationships that imports have with the domestic product. Mexican imports, the major source of imports into the U.S., enter the country tariff free. These imports compete favorably in the domestic shrimp processing market with domestic produced shrimp. Though some imports do enter the U.S. in a processed or semi-processed form, most enter as unpeeled, raw-headless shrimp, making them an excellent substitute for the same domestic product (Hu, 1983). Increased imports of maricultured shrimp may have a varied effect on the domestic market. Shrimp grown in controlled production systems are to a degree isolated from seasonal climactic changes which greatly affect natural production. Thus, cultured shrimp may be available year round, possibly reducing seasonalities in price. In addition, cultured shrimp imports will consist of very few size classes. Ecuador, for example, is producing primarily 31-35 count shrimp (Mock, 1982). Thus, markets for specific size classes may be impacted disproportionately. In an attempt to place a general upward pressure on ex-vessel prices, domestic producers have suggested initiating a tariff or quota system on imported shrimp products. Both policies have been shown empirically to have the effect of reducing the level of imports, thereby raising domestic prices (Prochaska and Keithly, 1983).

Processed shrimp products were valued at $1.1 billion in 1982, 24.5 percent of total value of all processed fishery products in the U.S. The impact of import restrictions through the use of a tariff or quota would have the effect of reducing the supplies available for processing and marketing. This reduction may have the effect of increasing the cost per unit processed as economies of size in processing are lost in

the short run. This would no doubt vary depending on the volume and form of product marketed (breaded, peeled and deveined, or canned). For example, breaded shrimp producers are more dependent on imports than producers of peeled or canned products. A reduction in imports may initially have a greater impact on the cost of producing breaded shrimp than other forms (Prochaska, 1983). The actual cost effect on prices at other market levels would further depend on how much of the cost is passed on to retail in the form of high prices, absorbed in the processor profit margin, or passed down to producers in the form of lower ex-vessel prices, if indeed, the processor has the ability to do so.

The dockside value of commercial U.S. shrimp production and the value of imports have also exhibited considerable change since 1960. Total value of the domestic commercial catch increased from $66.9 million in 1960 to $509.1 million in 1982, which represents nearly a sevenfold increase. From 1960 to 1970, the value of landings increased on an average annual percentage basis of 8.0 percent. Between 1970 and 1982, the annual rate increased to 13.4 percent. However, quantity landed exhibited only a 3.3 average annual percent increase between 1960 and 1982 (U.S. Dept. of Commerce(b), various years). Total domestic production and imports have remained relatively stable during the last four years, with imports showing a significant increase only in the last two years. Import value, on the other hand, has continued to increase since 1960. From 1960 to 1970, the value of imports increased from $36.4 million to $200.0 million in 1970, an average annual percentage increase of 13.9 percent. The value of imports continued to increase to $980.2 million dollars in 1982, an average annual increase of 16.4 percent. Preliminary estimates indicate that the 1983 value of shrimp imports was

$1,223 million. The rapidly increasing value of imports and domestic production reflects the tight market for domestic as well as import supplies in the last decade. The divergence between value and volume of landings is further highlighted by the 574 percent increase in the average ex-vessel price for all size classes per pound over the same period. This price increased only 86 percent between 1960 and 1974, but increased by 170 percent between 1975 and 1982.

The demand for shrimp products, and thus, consumer price, has been shown to be strongly related to disposable income on an annual basis (Doll, 1972; Hopkins, et al., 1980). Real disposable income in 1972 dollars in the United States increased 481 percent from $504 billion in 1961 to $1,060 billion in 1982 (U.S. Dept. of Commerce(a), 1983). Total retail and institutional expenditures for all shrimp products in the United States, excluding export revenues, was estimated to be approximately $3.8 billion in 1980 (Hu, 1983). In contrast, total expenditures for shrimp products was still less than $1 billion in 1975. Institutional (restaurant) sales accounted for 81 percent of the market in 1980, with 19 percent going to retail sales (food stores and retail grocery). The institutional share has remained at least 70 percent since 1960 (Hu, 1983).

Prices for raw-headless shrimp at the ex-vessel, wholesale, and retail levels for the 31-40 (retail prices represent only the 36-42 size class) and 21-25 size classes (tail count per pound) generally trended upward between 1968 and 1983 (Figures 1 and 2). During this 16 year period, however, prices, margins, and shares endured distinct periods of escalation, depression, and wide variability.

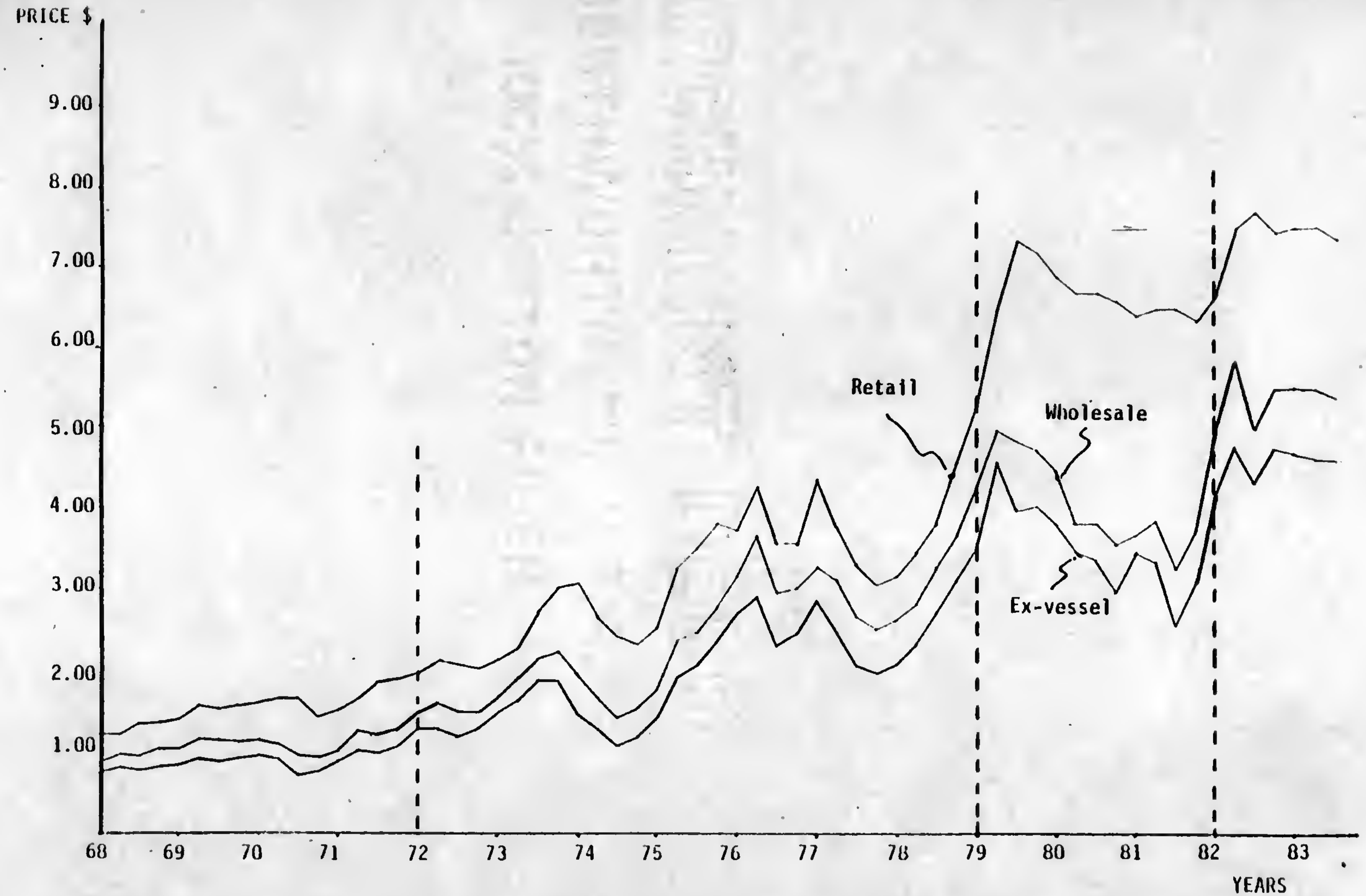

Figure 1. Trends in Quarterly Prices for 31-40 Count Raw-Headless Shrimp for Retail, Wholesale, and Ex-vessel Market Levels.

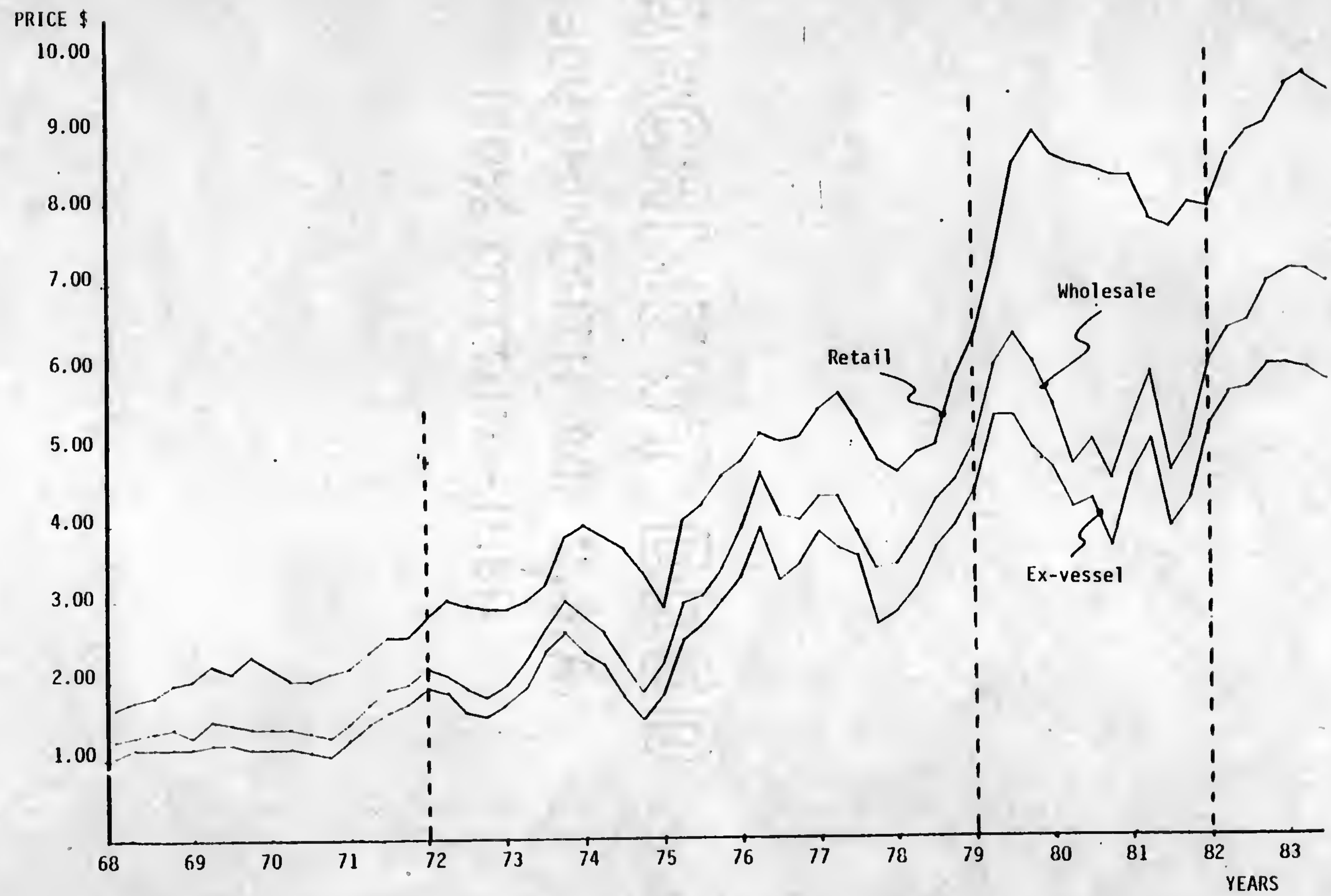

Figure 2. Trends in Quarterly Prices for 21-25 Count Raw-Headless Shrimp for Retail, Wholesale, and Ex-vessel Market Levels.

Prices were relatively stable from 1968 to 1972, particularly for the 31-40 size class. This reflects a period characterized by relatively stable real disposable income and uniform levels of domestic production and imports. During this period the retail/wholesale (M^{rw}) and wholesale/ex-vessel (M^{wp}) margins for the 31-40 size class exhibited a slight upward trend. The margins M^{rw} and M^{wp} had average values of \$0.50 and \$0.21, respectively. The 21-25 size class exhibited the same moderate upward trend in margins with M^{rw} increasing from \$0.41 to \$0.81, while M^{wp} increased from \$0.18 to \$0.36. Average values during this period for M^{rw} and M^{wp} were \$0.70 and \$0.24, respectively. Wholesale and ex-vessel share of retail dollar remained constant for both size classes, with an average wholesale and ex-vessel share of retail dollar at 71.5 and 58.8 percent, respectively, for the 31-40 size class, and 69.0 and 58.6 percent, respectively, for the 21-25 size class.

Prices for both size classes increased drastically and became much more volatile during the period from 1973 to 1978. Prices rose through 1973 and peaked in early 1974 as real disposable income increased and 1973 supplies were low. However, prices declined during 1974 as a real income declined. Domestic production remained low in 1974 but imports reached a record amount. Prices climbed again from 1975 to 1976. Record domestic production and imports in 1977 signalled a drastic decline in prices. However, prices climbed steadily throughout 1978 as total supplies fell off and real disposable income steadily increased. During this seven year period M^{rw} for both size classes varied considerably, while M^{wp} exhibited a stable upward trend. The margins M^{rw} and M^{wp} averaged \$0.75 and \$0.46, respectively, for the 31-40 size class, while M^{rw} and M^{wp} averaged \$1.04 and \$0.51 for the 21-25 size class.

Wholesale and ex-vessel share of retail dollars increased slightly during the period, with an average wholesale and ex-vessel share of retail dollar of 76.7 and 62.8 percent, respectively, for the 31-40 size class, and 75.3 and 63.9, respectively for the 21-25 size class.

The three year period from 1979 through 1981 witnessed rapidly escalating margins between retail and wholesale prices for both size classes, which were maintained even as wholesale and ex-vessel prices fell to a four-year low in 1981. Thus, in contrast to previous years, retail prices did not closely follow movements in wholesale and ex-vessel prices. Prices peaked in 1979 as domestic production reached a low equal to pre-1970 levels. In addition, real disposable income advanced steadily in 1979. In 1980 and 1981, total supplies of shrimp increased and prices continued to fall. However, retail prices for both size classes fell by a lesser amount in 1979 through 1981, resulting in a very large M^{rw} during this period. This large margin was maintained for nearly three years, being relinquished only in the last quarter of 1982. The margins M^{rw} and M^{wp} were both very erratic during this period. The retail/wholesale margin averaged \$2.46, compared to an average M^{wp} of \$0.57 for the 31-40 size class. The margins M^{rw} and M^{wp} averaged \$2.77 and \$0.78 for the 21-25 size class. During this same period, wholesale and ex-vessel share of retail dollar fell to 63.0 and 54.1 percent, respectively, for the 31-40 size class, and 66.0 and 56.5, respectively, for the 21-25 size class.

Prices at all three market levels resumed following one another more closely during the years 1982 and 1983. The margins stabilized during this period. The retail/wholesale margin averaged \$2.00 and \$2.28 for the 31-40 and 21-25 size classes, respectively. This can be

compared to a much smaller but increasing M^{wp} which averaged $0.81 and $1.03 for the 31-40 and 21-25 size class, respectively. As retail price remained rigid to advancing wholesale and ex-vessel prices, the wholesale and ex-vessel share of the retail dollars increased to an average of 73.1 and 62.1 percent, respectively, for the 31-40 size class, and 74.7 and 63.4 percent, respectively for the 21-25 size class.

Prices at all market levels have trended up since 1968 but major breaks in prices, particularly at wholesale and ex-vessel levels, occurred in 1974, 1977, and 1979. These periods were characterized by slackened demand brought on by reduction or fluctuations in real disposable income. When the economy is in a state of flux due to recessionary conditions, consumer real disposable income also fluctuates. As a result, demand for shrimp products and, thus, shrimp prices, are equally unstable (Prochaska and Cato, 1981). Record production in 1977 helped offset the low prices. During these periods vessel costs were increasing, further tightening the cost/price squeeze. The inflationary spiral which began in the early 1970's placed increased pressure on the profit margins of producers and processors. Fuel is now the major single cost component for shrimp vessels, accounting for 60 to 70 percent of the variable costs of a fishing trip. The high fuel requirements for the larger offshore boats placed many operators in financial jeopardy as diesel fuel exceeded a dollar per gallon. As a result, federal assistance in the form of fuel subsidies has been unsuccessfully solicited by vessel owners. The dramatic price recovery in 1978 and 1979 was negated to a great extent in real terms as costs skyrocketed during the same period. Interest rates on vessel loans, often a floating percentage through a Production Credit Association or local institution, exceeded

20 percent in some cases, significantly above prime rate. The last few years, as a result, have exhibited an increasing number of foreclosures. Some producers have been forced to suspend fishing or retrofit their vessel for alternative species, such as swordfish, shark, snapper, or grouper. Processors are also experiencing increased costs as labor, energy, and transportation costs climb. Creditors are becoming less willing to advance new loans or extensions on existing mortgages at a time when it is becoming increasingly necessary to obtain conversion financing or loan extensions.

Industry Issues

In recent attempts to stabilize the economic conditions in the domestic shrimp industry, several policy strategies are particularly noteworthy. The unsuccessful 1981 Breaux Bill (HR4041) was introduced as the "American Shrimp Industry Development Act." The purpose of this legislation was to provide shrimp producers a means by which to establish financing and implement a coordinated program of research, producer and consumer education, and market promotion in an attempt to "improve, maintain, and develop markets" for domestic shrimp products. The major provisions of the bill addressed the establishment of a tariff or quota system, establishment of regional market boards, and creating a comprehensive data reporting network. Federal opponents argued that most goals of the bill, with the exception of the marketing boards, were clearly within easy reach of the current management process.

The controversial Texas closure has generated varying results. Normally, the offshore Texas season is closed from June until mid July, out to nine fathoms. This leaves a large portion of the FCZ, which

extends out to 200 miles, open to shrimping. However, beginning in 1981, the entire FCZ was closed to shrimping except out to four fathoms with a 25 foot trawl. This represents an attempt to protect small shrimp and increase the average size shrimp caught, thereby increasing prices and gross revenues to the producer. The results in 1981 signalled a successful year with Texas landings and value up. However, the 1982 and 1983 closure brought just the opposite results. Texas producers questioned the uncertainty of the closure, especially since no fishing in the FCZ coupled with the possibility of minimum effect from the closure would be disastrous. Louisiana producers argued that Texas shrimpers would encroach on their traditional grounds during the closure. In addition, Louisiana processors argued that a supply glut may hit the market with less than efficient means to deal with the excess supply.

In general, the U.S. shrimp industry has exhibited decreasing catch per unit effort, increasing variability in producer price, and increasing costs of production. In addition, producers particularly have made a case that they are experiencing reduced profits. Though there appears to be no quick fix, several policy measures to address these problems exist, each with its own set of advantages and disadvantages. In an attempt to stabilize prices at a higher level, imposition of a tariff or quota system has been suggested. Theoretically, in the presence of import restrictions, prices should adjust to a higher level, with domestic supplies being more dependent on U.S. producers. However, the erratic nature of U.S. production may have the effect of increasing price volatility. In addition, lack of political endorsement, the questionable impact on processor cost structure and reduced supplies to

consumers, make this alternative a less than unanimous choice. A limited entry program, where the number of domestic producers is maintained at a lower than current level, has been suggested as a means by which production and profit per craft could be increased. This alternative provides a possible solution to the full-time producer's complaint of an increasing number of part-time producers. However, limited entry poses questions such as by how much should the existing fleet be reduced, which craft are to be eliminated, who bares the burden of costs of enforcement, and how will displaced capital be utilized? The latter issue is particularly noteworthy due to the degree of capital immobility in the shrimp fishery. Thus, each of these "solutions" brings with it a complement of issues to be dealt with, with no certain answers.

In summary, the U.S. shrimp industry has experienced a period of reduced growth beginning in the 1960's and extending through the 1970's. The industry has been characterized by volatility in recent years. Domestic production, imports and consumption demonstrated steady upward trends until the early 1970's. At that time, the trend disappeared and volatility set in. Thus, between 1970 and 1982, there appears to be little trend in supplies and consumption, but an increasing level of year-to-year variability. Prices and value, on the other hand, have maintained a fairly steady upward trend, but exhibited volatility in recent years. This trend may hold if world supplies reach a maximum and disposable income continues to increase. In addition, the increasing importance of Japan in the world shrimp market will provide for increased competition for limited supplies, causing further upward pressure on prices. Future supplies may be augmented, however, through the controlled production of maricultured shrimp in South America and Asia.

The U.S. shrimp industry, particularly the more important Gulf industry, is in a period of adaptation and transition. Recently, producers and processors have had to face rising fuel prices, increasing interest rates, growing levels of tariff-free imports, increased competition for domestic stocks, and a generally slackened economic situation on a national level. This has resulted in a number of vessels to either suspend fishing operations entirely or retrofit to seek stocks of alternative species. More widespread change can be expected as the industry adopts new harvesting, processing, and marketing techniques in order to become more profitable. Ultimately, the impact of this change is reflected in th price paid and received in the producer, wholesaler-processor, and retail markets. Understanding how these impacts are transmitted through the pricing system and their order of magnitude is of crucial importance to management and trade policy formulation. Before the impact of the change can be fully understood, an understanding of how prices and margins are determined in the market place is vital.

Problem Statement

The Magnuson Fisheries Conservation Management Act (MFCMA) of 1976 (PL 94-265) has charged policy makers with the efficient management of the U.S. seafood industry, including the shrimp fisheries through the use of regional fisheries management plans. To accomplish this task, directives must be oriented toward biological, social, and economic issues. Consideration of one without the other may lead to invalid conclusions and inefficient policies. Developers of management plans are required to trace impacts of proposed legislation throughout the

market system. Imperative to the economic component of a given management plan is the understanding of the structure, conduct, and performance of seafood market systems. This includes an understanding of the dynamics of price formulation in terms of the time, space, and form characteristics at each level of the seafood market. A better understanding of the existing shrimp marketing system is necessary for the obtainment of the overall objective of the MFCMA.

The shrimp industry is the most valuable domestic fishery in dockside dollars in the United States. This particular industry has recently exhibited considerable price volatility and instability throughout the market system. A host of factors have contributed to this state of flux, such as fluctuating demand, tight world and domestic supplies, changing market structure, increasing dependence on imports, increasing costs of production, and fluctuating domestic economic conditions. Changing market conditions appear to have left the producer bearing the brunt of an array of economic symptoms. The symptoms which are being expressed by producers, such as relatively depressed dockside prices and reduced revenues, have motivated interest in several management policies to help bolster demand for domestic products and, thus, act as price supports (i.e., import tariff, import quota, limited entry, and promotional programs). In addition, the apparent concentrated nature of the shrimp wholesale/processing market level (less than 20 firms control approximately 90 percent of total U.S. output) may provide for some market power in terms of gathering and assessing market information. This may provide for a competitive advantage over firms in their own market level and also provide an informational advantage over firms in adjacent market levels. The recognition of the possible oligopolistic

nature of the wholesale/processing sector may provide insights into the price determination process at each market level. In addition to possible monoposonistic pricing, the concentrated nature of the processing sector may result in price leads and lags in the market place, with the market level possessing more timely and accurate information acting as a price leader. The market level with the information edge may be able to exploit this position in the price determination process to gain greater profits relative to adjacent market levels. The existence of this phenomenon is at least implied by recent legislation calling for aid in establishing cooperatives and market orders in the producer sector.

Before the economic appropriateness of a tariff, quota, or limited entry program can be accurately assessed, an understanding of price dynamics is vital. This knowledge will provide a more clear view of how these policies will impact the various market levels.

Studies done to date concerning the U.S. shrimp market system have provided some insight into the mechanism of the structural components of the system in an effort to understand market price fluctuations (Doll, 1972; Hopkins et al., 1980; Thompson and Roberts, 1982; Gillespie et al., 1969; Prochaska and Keithly, 1983). Previous research has provided a partial understanding of how imports, domestic business and economic factors, and biological elements impact the pricing system. Limited explanatory power has resulted. More importantly, contradicting model specifications in terms of the direction of price determination are evident in some of the previous major studies. No formal research has been undertaken to employ current methodology regarding price causality in the U.S. shrimp market system. In addition, no formal research has been carried out regarding the presence or absence of asymmetric price

response, speed and magnitude of price adjustment between market levels, and the determinants of prices and marketing margins. Further research must be performed to provide insights into the sensitivity of price transmission in a time (speed of adjustment), space (region of market), and form (size and degree of processing) framework. Policy makers need to understand the dynamics of price determination and transmission in the market and the impact to producers, processors, retailers, and consumers that increased control over prices in the market may produce. A more fundamental knowledge of price linkages would provide further understanding of how market levels interact and relate given stimuli internal and external to the market system.

Objectives

The purpose of the research is to investigate and model the dynamics of price transmission between the producer, wholesale, and retail levels of the U.S. shrimp market system on a size class basis for raw-headless shrimp. This will be accomplished by developing an econometric model of the prices and marketing margins. Primary emphasis is placed on examining the dynamics of price for each market level and price transmission between market levels. Insights, are developed into the nature of the price adjustment process between market levels. Specifically, the objectives of the research are

(1) to determine the univariate time series characteristics of the price series for each market level (producer, wholesale, and retail) by size class (31-40 and 21-25 count shrimp),

(2) to identify the direction of price determination between adjacent market levels for the producer, wholesaler, and retail markets for each size class of shrimp in the market system,

(3) to examine speed of price adjustment between market levels for each size class,

(4) to determine if price adjustment between market levels is symmetric or asymmetric for each size class, and

(5) to identify major determinants of price and test hypotheses regarding price relationships between market levels.

CHAPTER II
THEORETICAL CONSIDERATIONS

This chapter provides a brief discussion of the competitive market, with emphasis given to the vertical structure. The dynamic properties of price, such as the direction of price determination and lead/lag relationships are discussed to provide an understanding of how actual markets may depart from the static competitive model. Specifically, causality between market levels in a vertical market system, the nature of price spreads, and the importance of the mechanics of price transmission between levels in a vertical market system is stressed. Thus, this section provides a motivation for the modelling approach.

Vertical Structure

Bain (1964) discusses the market system as a means by which natural resources, productive facilities, and labor forces are developed and assembled to determine what and how much is to be produced and how the goods and services are to be distributed to users. Cochrane (1957) defines a market as a sphere or space where the forces of demand and supply interact to determine or modify price as the ownership of some quantity of goods or services is transferred with certain physical and institutional arrangements in evidence. In a perfectly competitive sense, many buyers and sellers come together to negotiate regarding a homogenous product with perfect information, no rivalry, and with freedom to enter or leave the market. As Kohls and Uhl (1980) argue,

arbitrage would result in an instantaneously determined unique equilibrium price for any quantity of goods representing a given time, location, and product form. Price formulation is a static process in this setting (Heien, 1980).

When using the above concept of the market, one can visualize a benchmark case where a single equilibrium market price is established at which the quantities offered for sale by producers exactly equals the quantities demanded by purchasers. The situation would only be true in the simplest of markets where the original producers and final consumers are involved in a direct arbitrage. Most agricultural commodity markets are far more complex. In most markets, initial producers and final consumers are separated by a complex vertical network of intermediate processors, handlers, wholesalers, brokers, and marketing agents, each exhibiting its own input demand and output supply. In this sense, initial producers and final consumers do not face one another directly; rather market signals must pass through the market system whether the signal originates from the final consumer, initial producer, or intermediate agent. Often, consumer demand is not for the primary product but for the primary product plus the utility derived from additional characteristics added through processing and the necessary marketing services. Thus, consumer demand is a direct demand for a final good such as breaded shrimp, as opposed to a raw-headless shrimp. The demand for the primary product is derived from the demand for the final good.

The Marshallian consumer demand for a final good is simply the quantity demanded by an individual (i) consumer over a given set of prices and a fixed income level (ceteris paribus) given as

$$D_i = f(P, Y)$$

where P is a vector of prices $P_1, \ldots, P_j$ and Y is income. Each D_i is assumed to be a demand function homogenous of degree zero in prices and income and monotonically decreasing in price (Deaton and Muellbauer, 1980). The market (consumer) demand, or "primary" demand for the market then is the horizontal summation, of individual consumer demands D_i.

Demand exhibited by wholesalers, processors, and producers is derived demand. The demand is for the original good to be used as an input in a higher level in the market system. In other words, producers face the demand for their product by processors, who will in turn utilize the product as input. The demand by an individual processor for the input is given as the value of marginal product (marginal product of input multiplied by the market price of the processed good). In a strict sense, this is only true when one input is utilized. When more than one input is utilized in the production of the processed good, substitution, output, and profit-maximizing effects must be considered (Gould and Ferguson, 1980). Similarly, when summing individual processor's value of marginal product functions to arrive at the market demand, a possible change in market price of the processed good from simultaneous expansion or contraction of all processors must be considered. Thus, the derived market demand for the processor level is not simply the horizontal summation over all processors of their value of marginal products for the input.

Similarly, the supply faced by the market levels is derived supply. These supply relationships are derived from the primary supply of the producer and are best defined as the supply of intermediate goods (i.e. processor output).

The intersection of primary producer supply and the final consumer demand is of no real importance in a market where the product must go through some transformation or processing to final form. The price resulting from such an equilibrium would suggest that processing and marketing services are rendered at zero cost. Thus, market equilibrium is actually determined through the simultaneous equating of the supply and demand for the initial product plus marketing services. For most actual markets, there may be several levels, each representing different stages of processing or handling. At each level within the vertical market, a representative equilibrium price exists which represents the equating of the derived or primary supply and demand at that level and reflects value added through processing and marketing services up to that level in the market system.

Representation of a conceptual model of vertical markets is provided in Figure 3. Primary demand at the retail, derived demand at wholesale, and derived demand at producer level, are represented by R^d, W^d, and F^d, respectively. Primary supply at producer level, derived supply at wholesale level, and derived supply at retail level, are represented by F^s, W^s, and R^s, respectively. Retail, wholesale, and producer level prices which result from the solution of the six demand and supply equations representing the three market levels are denoted by p^r, p^w, and p^f, respectively. Note that an equivalent quantity of good Q is being traced through the market system, making adjustments for processing inputs and product loss at each stage of processing. In actual markets there may be several stages of processing. In addition, alternate channels may exist depending on the ultimate form and market of the raw good. Thus, sub-markets may be defined, each with its own

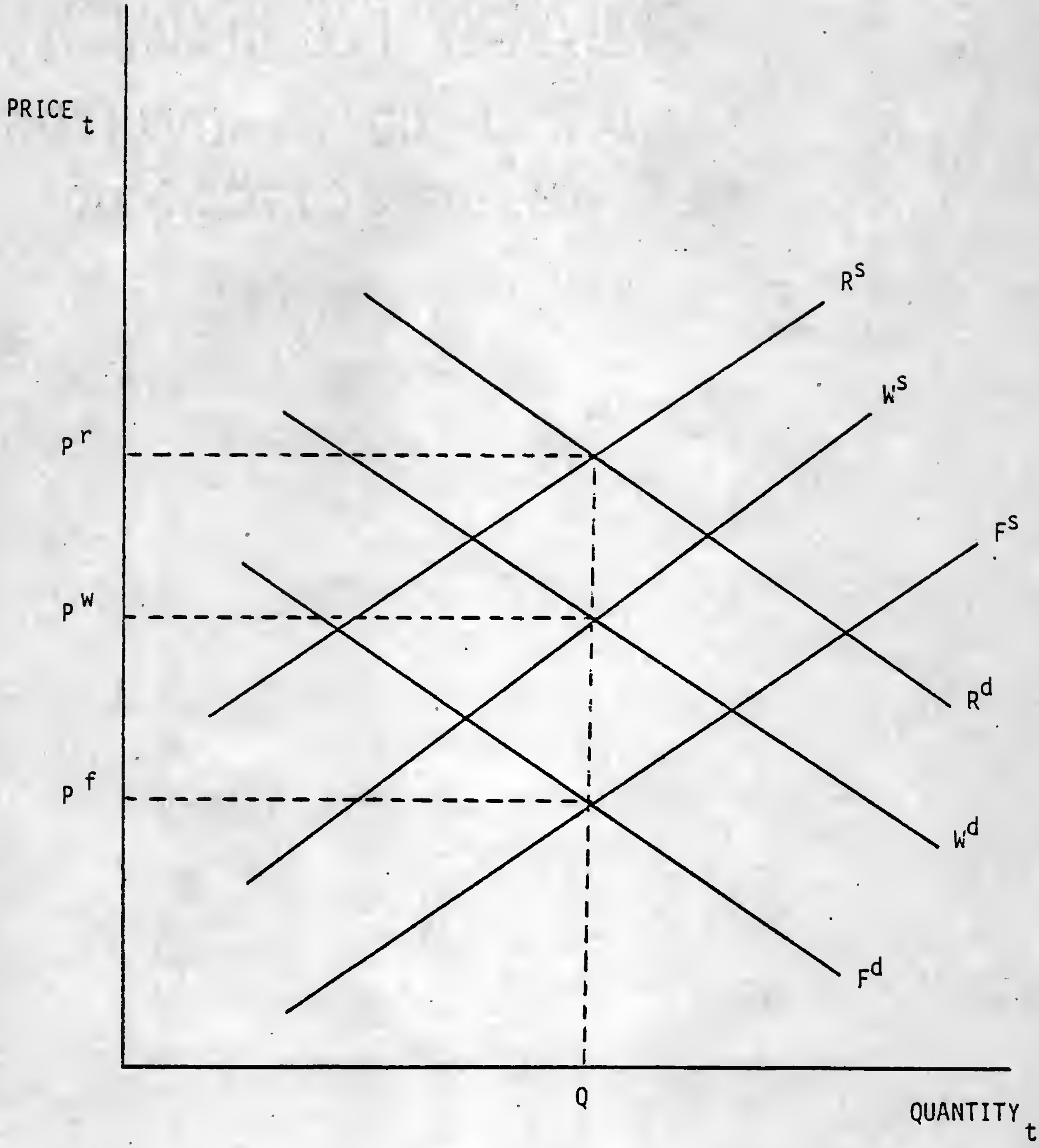

Figure 3. Graphical Representation of a Vertical Market System with Equilibrium Prices p^r, p^w, and p^f in Time Period t.

price which reflects equilibrium between two adjacent submarkets; i.e., producer and first handler, first handler and processor, processor and wholesaler, wholesaler and retailer, and retailer and consumer. As Bressler and King (1978) point out in a competitive framework, all of these stages and prices are interdependent and determined simultaneously in a single market context with multiple prices. Therefore, vertical market equilibrium prices dictate the simultaneous equating of supply and demand for goods and services across the various market levels. Bressler and King, however, do not discuss the possibility that alternative market organization or the time frame of analysis may warrant the price determination process to be viewed more appropriately as a recursive lead/lag process, rather than simultaneous.

Gardner (1975) presents a basic theoretical methodology for the determination of retail and farm price. This competitive model is an extension of the Allen (1938) and Hicks (1957) one product two input model and provides a means by which quantifiable predictions can be made regarding the impact that changes in demand and supply of food products would have on the retail-farm price ratio and the farmer's share of retail food expenditure. The model is developed in a static equilibrium framework. Gardner's static approach implies shifts in supply and demand would result in instantaneous shifts in price with no concern given to the time path of adjustment. In relaxing the static setting Heien (1980) develops a price determination model that allows for disequilibrium in the retail, wholesale and farm market levels. In particular, Heien argues that as the time period of analysis becomes shorter, the dynamics of prices (i.e. speed and magnitude of adjustment, asymmetry, and causality) become important. Watson (1963) notes that leads

and lags in pricing associated with disequilibrium are consistent with perfect competition in the short run. Thus, issues regarding the dynamics of price transmission (lead/lag structures) become important when addressing pricing efficiency on a timeliness and accuracy basis for the short run movement in prices (Sporeleder and Chavas, 1979). As such, a dynamic rather than a static approach may be more appropriate when examining the transmission of prices between producer, wholesale, and retail levels in the market place when using weekly or monthly rather than quarterly or annual data. The price transmission model presented below relates to Figure 3.

The retail (primary) demand for the final product is given by

(1) $R^d = f(p^r; V)$

where R^d is quantity demanded at retail by consumers, p^r is retail price, and V is a set of exogenous factors which affects consumer demand, such as income. The retail (derived) supply for the finished product is given as

(2) $R^s = f(p^r, p^w; X)$

where p^w is wholesale price of the processed product and X is a set of exogenous factors such as the cost for marketing services.

The wholesale/processor level in the model is characterized by derived relationships of the demand and supply sides of the market. The wholesale demand is a derived factor demand from the retail level for the wholesale/processor component of the final good. This relationship is given as

(3) $W^d = f(p^r, p^w; X)$

The supply relationship at the wholesale/processor level is derived from the producer level in equivalent units. This supply is given as

(4) $W^s = f(p^w, p^f; Y)$

where p^f is producer price and Y consists of other wholesale costs, such as storage.

The producer demand, which is derived from the wholesale demand for producer output, is given as

(5) $F^d = f(p^w, p^f; Y)$

The primary supply as an aggregate of producer output is given as

(6) $F^s = f(p^f; Z)$

where Z is a set of exogenous factors affecting production, such as weather.

When the market is assumed to be in equilibrium, i.e., $R^d = R^s$, $W^d = W^s$, and $F^d = F^s$, partial reduced form expressions for retail, wholesale, and producer prices can be obtained from solving 1 and 2, 3 and 4, and 5 and 6, respectively, yielding

(7) $p^r = f(p^w; V,X)$

(8) $p^w = f(p^r, p^f; X,Y)$

(9) $p^f = f(p^w; Y,Z)$

which are fully simultaneous in prices. In Gardner's static competitive model, these reduced form expressions for price are assumed to adjust instantly to changes in raw product supply, supply functions of marketing services, or retail food demand. In addition, Gardner suggests that simple markup rules in pricing at each market level are not adequate

enough to accurately model price determination processes. Heien, however, advocates the viability of markup pricing rules with a model incorporating short run disequilibrium such that $R^d \neq R^s$, $W^d \neq W^s$, and $F^d \neq F^s$. In this situation the time path of price adjustment becomes important as time inherently becomes one of the exogenous factors in price determination. Heien further suggests that price changes are passed unidirectionally upward through the pricing system via a markup policy at each market level, which he shows is consistent with firm optimization behavior. Thus, a lead/lag price determination relationship between market levels may arise. In the Gardner model, the direction of causality, which may ultimately be an empirical question, is indeterminate, or assumed non-existent, due to the implied simultaneous specification. Given the presence of highly competitive markets, auctions, and the increased use of computerized marketing techniques, rapid and simultaneous adjustment of prices to changes in supply and demand may be valid. However, in less competitive and less organized markets, such as those for many seafood products, the notion of short run disequilibrium and the possibility of prices needing time to equilibrate warrants the investigation of the resulting dynamic properties of price transmission and causal direction as prices move between equilibrium points among market levels in a lead/lag fashion.

Disequilibrium is particularly of interest in markets where price supports and production control exist. Though most seafood markets (shrimp being no exception) are not as yet subject to these management policy measures, Bockstael (1982) has applied disequilibrium models to various domestic seafood markets with some success. In markets where disequilibrium is a result of erroneous or delayed informational

signals, stability implies that the market will eventually equilibrate to the static equilibrium point through some lag recursive adjustment process (Silberberg, 1978). A stable market then will result in long run and static adjustment tending to produce the same equilibrium point. Ward (1982) suggests that increased concentration at one market level may provide that level with a competitive edge in assessing market information. This advantage effectively allows that market level to react before other market levels and establish a pricing lead. Miller (1980) attributes the lead/lag pricing structure to increased use of formula pricing, demise of terminal markets, and general structural changes in the market.

An attempt to directly estimate and interpret a set of reduced form expressions, such as represented by equations 7, 8, and 9, will be frustrated in that the signs of the parameter estimates will be ambiguous. This is due to the parameter estimate being unspecified as to whether the representative shock originated from a supply or demand shift (Chiang, 1974). In this sense, the above expressions for prices p^r, p^w, and p^f are not sufficient for testing hypotheses regarding lead/lag relationships and determinants of prices and margins. A more appropriate strategy for a study of price determination would be to conceptualize a model that will yield structural price expressions at each market level that are directly estimable.

A conceptual model of a vertical market system for shrimp products is given in Figure 4. This market system has four linkage points of adjacent market levels: consumer/retailer, retailer/wholesaler-processor, wholesaler-processor/first handler, and first handler/producer. These market level interfaces are particularly characteristic for the

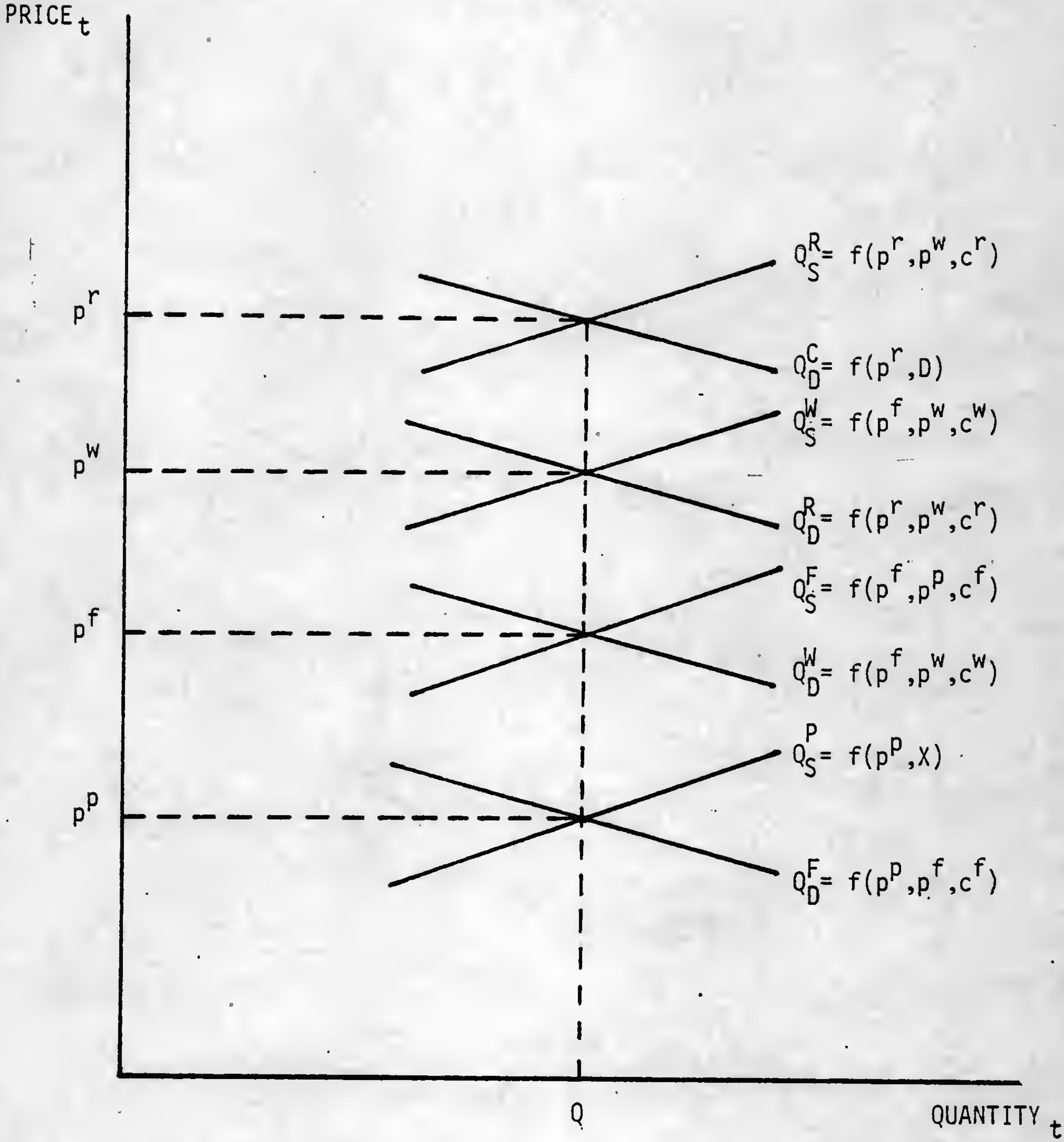

Figure 4. Graphical Representation of a Vertical Market System with Supply and Demand Given Implicitly at Four Market Levels and the Corresponding Equilibrium Prices p^r, p^w, p^f, and p^p in Time Period t.

domestic shrimp market where most shrimp produced domestically are off-loaded by a fish house (first handler) and sold to a wholesaler and/or processor. The first handler for imported product is normally a broker. The domestic and imported product is then processed under retail or processor brand name and sold to the retail market.

The consumer's demand for retail product is given as

$$(10) \quad Q_D^C = f(p^r, D)$$

where Q_D^C is quantity demanded, p^r is retail price paid by the consumer, and D is a set of demand shifters which would represent income, price of substitutes, etc.

The retailer's supply of retail product to consumers is given as

$$(11) \quad Q_S^R = f(p^r, p^w, c^r)$$

where Q_S^R is quantity supplied, p^w is wholesaler-processor price or price of retail input paid to the wholesaler, and c^r is prices for marketing inputs utilized by the retailer in transforming the product to a shelf ready product. The retailer demand for product from the wholesaler-processor is given as

$$(12) \quad Q_D^R = f(p^r, p^w, c^r)$$

where Q_D^R is quantity demanded, which is the same function as for Q_S^R. The similarity between Q_S^R and Q_D^R is valid in terms of the theory of the firm as Q_D^R represents the input demand of a retail firm and Q_S^R represents the output supply of a retail firm. These two relationships will be functions of the same variables; i.e. input and output prices, under profit maximizing behavior (Silberberg, 1978).

The wholesaler-processor's supply of product to retail firms is given as

$$(13)\quad Q_S^W = f(p^f, p^w, c^w)$$

where Q_S^W is quantity supplied, p^f is first handler price or the price paid by wholesaler-processors to the first handlers or fish house owner, and c^w is prices for marketing inputs utilized by wholesaler-processors in transforming the product as received from the first handler to the product purchased by retail firms. The wholesaler-processor firm's demand for product from first handlers is given as

$$(14)\quad Q_D^W = f(p^f, p^w, c^w)$$

where Q_D^W is quantity demanded. The expressions Q_S^W and Q_D^W are functions of the same variables, and represent supply and demand, respectively, for a wholesaler-processor firm.

The first handlers supply of product to wholesaler-processors is given as

$$(15)\quad Q_S^F = f(p^f, p^p, c^f)$$

where Q_S^F is quantity supplied, p^p is the price paid by the unloading or fish house to the boat, and c^f which is the price of marketing services used by the fish house. The actual price per pound for the catch may vary, depending on whether the shrimp is sold after being sorted by size (pack-out) or sold on an average size per pound (box-weight) basis (Nichols and Johnston, 1979). The first handler's demand for raw product from producers is given as

$$(16)\quad Q_D^F = f(p^f, p^p, c^f)$$

where Q_D^F is the quantity demanded and which is given in terms of the same variables as Q_S^F.

The producers supply of raw product to first handlers is given as

$$(17) \quad Q_S^P = f(p^P, X)$$

where Q_S^D is the quantity supplied and X is a set of exogenous supply shifters, such as weather.

By assuming that inventories remain relatively stable over time, the quantity supplied at each market level is determined by the equilibrium quantity determined in the raw product market. Given that the supply of raw shrimp product is determined in the short-run primarily by environmental conditions affecting the domestic production and by world market conditions affecting the supply of imports offered to domestic brokers, the supply of raw product to each market level is relatively price inelastic (Doll, 1972; Hopkins et al., 1980; Grant and Griffin, 1979). Conceptualizing the market in this manner, and not addressing the issue of inventories in any further detail, a set of price dependent demand expressions depicted in Figure 5 are given as

$$(18) \quad p^r = f(Q_D^C, D)$$

$$(19) \quad p^w = f(p^r, c^r, Q_D^R)$$

$$(20) \quad p^f = f(p^w, c^w, Q_D^W)$$

$$(21) \quad p^P = f(p^f, c^f, Q_D^F)$$

which can be derived for the retail, wholesale, first-handler, and raw product market, respectively. Prices are now dependent on quantity (supply) at each market level. Normalizing demand expressions on price has been shown to be appropriate for agricultural products. Houck (1966, page 225) states that "although individuals make quantity

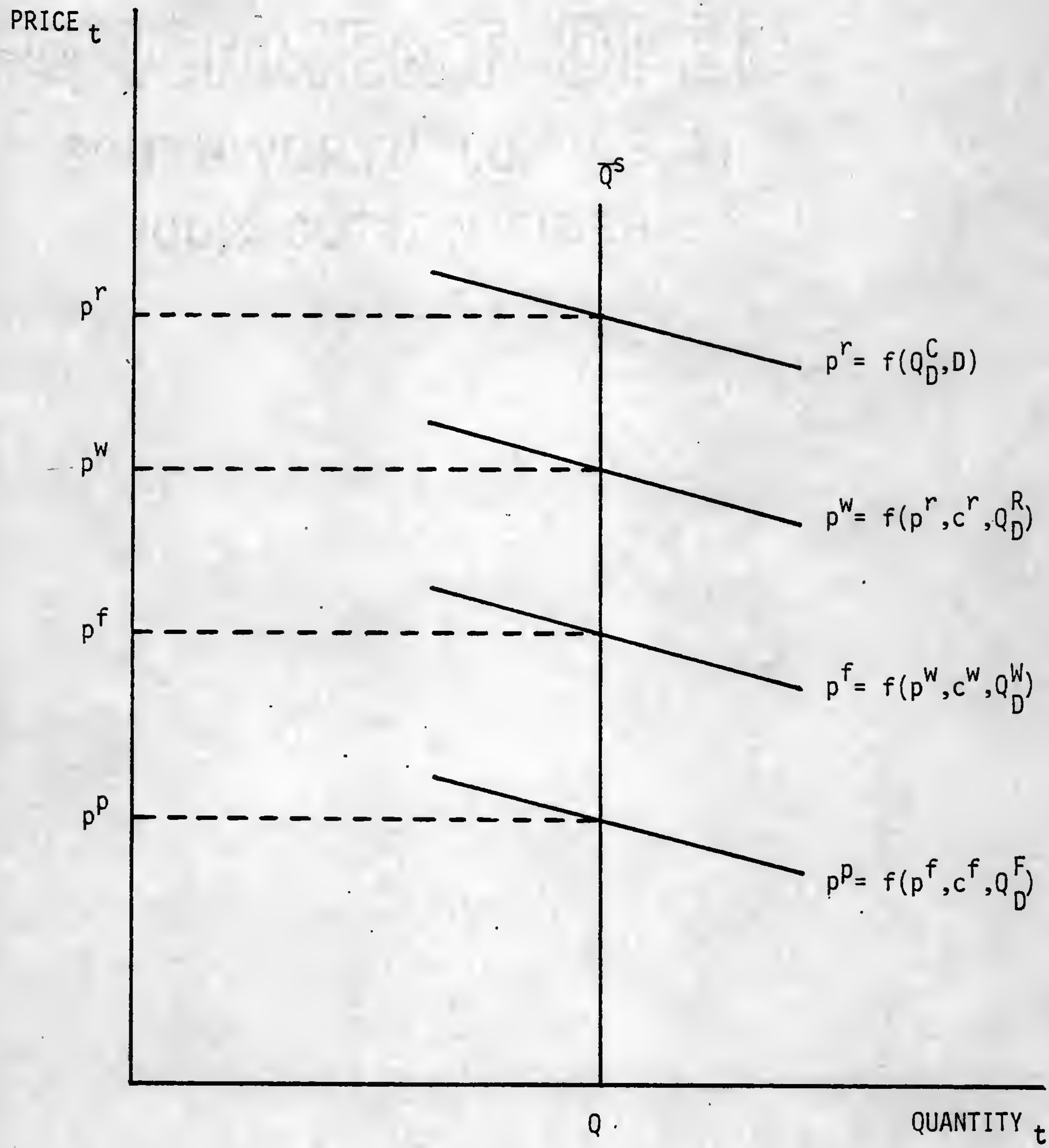

Figure 5. Graphical Representation of a Vertical Market System Characterized by Inelastic Supply with Demand Given Implicitly at Four Market Levels and the Corresponding Equilibrium Prices p^r, p^w, p^f, and p^p in Time Period t.

decisions based on given prices, market supplies of many agricultural products are so fixed in the short-run that prices must bear the entire adjustment burden." This argument for estimating price flexibilities applies to many seafood products, particularly to shrimp, as supplies are often determined by non-price factors and can be considered exogenous. Thus, a set of structural price dependent demand expressions, with an exogenous inelastic supply, can be derived that lend themselves to unambiguous interpretation of parameter estimates--an improvement over reduced form estimates.

Expressions (18) through (21) are restrictive in the sense that price determination is recursive from retail to raw product markets. Certain structural attributes of the market and alternative pricing policies of marketing agents may dictate a different price determination process; i.e., upward recursive, a pricing locus or node at an intermediate market level, or simultaneity. Thus, a more general expression of equations (18) through (21) with supply at each market level assumed exogenous would be

$$(22)\quad p^r = f(p^w, Q_D^C, D)$$

$$(23)\quad p^w = f(p^r, p^f, c^r, Q_D^R)$$

$$(24)\quad p^f = f(p^w, p^p, c^w, Q_D^W)$$

$$(25)\quad p^p = f(p^f, c^f, Q_D^F)$$

However, properly specifying which prices are endogenous, lagged endogenous, or exogenous relative to the price expression representing a given market level may not be possible based on a priori knowledge of the market. Thus, whether the vertical market price determination

process is characterized by instantaneous interdependent (simultaneous) price shifts in a static competitive manner or whether unidirectional relationships exist in a fully downward, fully upward, or an intermediate nodal form may very well be a theoretical question which requires empirical support.

Causal Direction of Price Determination in the Vertical Market

In attempting to estimate equations 22 through 25, the model must be specified in either seemingly unrelated, recursive, block recursive, or fully simultaneous form. In doing so, restrictive implicit assumptions (maintained hypotheses) regarding the direction of price determination (causal) structure of the price series are imposed. A more general representation of the structural price equations could be given as

$$(26) \quad p^r = f\ (M_1;\ Q_D^C,\ D)$$

$$(27) \quad p^w = f\ (M_2;\ c^r,\ Q_D^R)$$

$$(28) \quad p^f = f\ (M_3;\ c^w,\ Q_D^W)$$

$$(29) \quad p^p = f\ (M_4;\ c^f,\ Q_D^F)$$

where M_i represents a set of prices consisting of subsets of endogenous, lagged endogenous, and exogenous prices. Testing for the causal relationships between prices provides for the identification of the subsets of each M_i. Though economic theory suggests the structural specifications of the model, a priori information may not be detailed enough to suggest the exact specification of leads, lags, and other dynamic components, thus leading to model misspecification. Orcutt (1952, page

306) provides three motivations for determining the causal nature of the relations of an economic system:

(1) Policy implications of any relation depend critically upon whether the relation holds in one or more directions,

(2) Methods which are not designed to recognize the directional nature of relations will often lead to acceptance of a relation as non-directional when on the basis of available data, only a more restricted causal relation is justified, and

(3) If we do not use techniques adapted to finding causal, as contrasted to non-directional, relations, we may fail to find relations which actually exist and which could be found on the basis of available data.

If there exists a strong causal structure that is not embodied in the structural specification of an explanatory model, the possibility of biased and inconsistent parameter estimates exists. Bishop (1979, page 2) states that "given the potentially serious problem with simultaneous equations bias when a simultaneous system is estimated by a single-equation method, it is important to ascertain the causal structure." This is no less true when modelling in a dynamic lead/lag framework. Sims (1972, page 540) notes that "most efficient estimation techniques for distributive lags are invalid unless causality is unidirectional" in the Granger sense. Thus, testing the implicit causal assumptions on which most single equations or systems regressions are based is of vital importance. Strotz and Wold (1960) emphasize that this is particularly true when dealing with explanatory rather than descriptive "curve fitting" models.

The direction of causality as dictated by the theory is a debateable topic. Colclough and Lange (1982) express a theoretical basis for questioning the direction of causality. They state that

> a theoretical basis for questioning the finding of unidirectional causality from producer to consumer prices also exists. Derived demand analysis specifically yields a model of price causality from the consumer price level to the producer price index. This analysis has gone surprisingly unnoticed and untested. Consider supply costs and the determination of the cost of production. The producer pays the opportunity cost of resource or the services of resources in order to acquire input. The opportunity costs of resources reflect the demand for input between competing uses. It is the demand for final goods and services that generates the opportunity costs of resources and intermediate materials. This suggests causality from consumer prices to producer prices (page 380).

Heien (1980), on the other hand, suggests that the competitive market dictates the direction of causality from producer to consumer through markup pricing rules. Bishop (1979) reiterates this confusion over the direction of causality by stating

> Some assume that changes in prices at the farm level lead to changes in the wholesale and/or retail prices. Others assume that because of the nature of the food processing industry, no strong relationship exists between producer and retail food prices (page 1).

Van Dijk (1978) points out that the theory of price formation in the vertical market system does not provide an unambiguous indication of the short-run cause and effect nature of prices. When retail prices lead producer prices, derived demand would appear to be manifesting itself in the market place. Alternatively, when producer prices lead retail prices, an adaptive pricing or markup policy may be evident. Van Dijk suggests that this scheme is not clear cut in that derived demand may result in producer to retail price movements if producers are anticipating future demand conditions.

Causality is often referred to as a time related phenomenon and its presence (in a unidirectional sense) implies recursiveness (Van Dijk, 1978). Thus, the sampling interval of the data relative to the changes

in the "lead" and "lag" variables may obscure the identification of a recursive structure. An apparent interdependent instantaneous change, or simultaneity, may be an appropriate inference if the sampling interval exceeds the time lapse of response between lead and lag variables. In this sense, daily, monthly, quarterly, or annual data may suggest different price determination processes. This information, however, would be no less helpful in correctly specifying a "long run" versus a "short-run" model.

There have been numerous studies investigating the direction of causality in agricultural markets (Bessler and Schrader, 1980a; Miller, 1980; Ward, 1982; Ngenge, 1982; Grant, Ngenge, Brorsen and Chavas, 1983; Spreen and Shonkwiler, 1981; Van Dijk, 1978). Additional studies have analyzed markets at the macro-level using price indices (Silver and Wallace, 1980; Sims, 1972; Colclough and Lange, 1982). However, no studies have been done to test the direction of price causality between vertical market levels in the seafood market of the U.S. Before a model for the U.S. shrimp market, such as that represented by equations (26) through (29), can be specified and estimated to address the issue of the dynamics of price determination, the causal properties of the price determination process must be identified.

Price Spreads Between Market Levels

Tomek and Robinson (1972) point out that a price spread or marketing margin may be defined alternatively as (1) the difference in price ultimately paid by the consumer for the final product and price received by the producer for the raw goods or (2) the price or cost of the collection of processing inputs and marketing services added to the raw

product. Both can be viewed as the price response to some markup rule which is a function of the supply and demand for the marketing input. A price spread then is the difference between the price associated with two market demands adjacent or otherwise, relative to an equivalent quantity of goods. Retail margins would be the difference between the price paid by the retailer to the wholesaler and the price received by the retailer from the consumer, i.e., $p^r - p^w$ in Figure 3. Wholesale margins would be the difference between the price paid by the wholesaler to the producer and price received by the wholesaler from the retailer, i.e., $p^w - p^f$ in Figure 3. In an actual market setting, the spread between two prices would typically consist of wages, transportation costs, interest, processing, charges for marketing or handling services, and profit markup necessary to provide for an acceptable rate of return. In a competitive model, excess profit is dissipated to zero, or normal profit.

The price found at the primary demand level (retail) or a derived demand level above the producer level consists of two components— (1) producer related components and (2) processing and/or marketing related costs. As pointed out by Fisher (1981) and Friedman (1962) this margin concept operates under the assumption of fixed proportions in processing and marketing which implies elasticity of substitution (σ) between all goods and marketing/processing inputs equal to zero. Recent studies by Gardner (1975), Fisher (1981), and Heien (1980) have produced more general models where $\sigma \neq 0$. In addition, dynamic lead/lag price spread adjustment has been investigated through use of inventory disequilibrium models (McCallum, 1974).

Gardner identifies the major determinants of the price spreads as farm product supply, the supply functions of marketing services, and retail food demand. For example, given a perfectly elastic supply for marketing services, a shift in demand for marketing services would result in no changes in the margin, as suppliers of marketing services would be price takers. However, a less than perfectly elastic supply function would result in a changing margin as prices of services increase commensurate with increases in demand for services. Tomek and Robinson (1972) argue that derived demand and supply curves shift as the cost of existing marketing services increase or as the supply of marketing services shift. Each of these factors will have an impact on the margin at given quantities as demand at different market levels converge or diverge. Alternatively, the demands may be parallel to each other, which implies that marketing costs, and thus margins, do not change over the range of quantities marketed.

Shifts in product prices at a given market level are, in an efficient competitive setting, fully and immediately reflected in prices at higher market levels. Thus, a competitive model will show no relationship between margin changes and shifts in raw or processed prices (McClements, 1972). Given this mechanism, market signals are passed through the vertical system instantaneously and without distortion allowing market participants at each level to make rational decisions.

In addition, competition dictates that the costs of marketing services just exhaust the margin between two demands. Changes in costs of marketing services are reflected in an equal change in the margin (Van Dijk, 1978). How this change is distributed between the interfacing market levels (incidence) is a function of the relative price

elasticities of demand and supply at each market level. The question of who bears the margin shift is particularly important to trade policy. As Fisher (1981) points out, for most agricultural products, the major adjustments which result from a shift in marketing margins will be borne by producer prices. Thus, producers have a strong economic motive for establishing some influence over cost efficiencies in the processing level of the market system.

The price formulation policy to be used at each market level is dependent on a number of factors including firm policy and objectives, i.e., following the leader pricing, staying abreast of competition, or short run profit maximization (Dalrymple, 1961). George and King (1971) discuss other forms such as average cost, experimental, or intuitive pricing methods. Griffith (1975) and van Dijk (1978) discuss at great length the phenomenon of price leveling and its causes and consequences. These forms of pricing behavior are referred to as nonsystematic. On the other hand, systematic pricing methods are evident when the margin is determined by an absolute markup and/or percentage markup. These markups may be either constant or variable as quantity changes. Studies by Waugh (1964), Beck and Mather (1976), Etheridge (1975), Prochaska (1978) and Bockstael (1977) have addressed these two margin components. Shepherd (1955), Rojko (1957), and Gardner (1975) suggest that most margins are a combination of the two components. However, Dahl and Hammond (1977) and Dalrymple (1961) assert that wholesalers typically use constant percentage markups while retailers use a constant absolute markup.

Price Transmission

One characteristic of a competitive market is that prices are transmitted efficiently through the vertical market system. Brorsen (1983) points out that efficient price transmission can be thought of as exhibiting a minimum of lags and distortions. This is important as price serves as the market signal that relates changing demand and supply conditions between consumers and producers. In this sense, Sporleder and Chavas (1979) point out that pricing efficiency implies optimal resource allocation, minimum cost levels, and efficient distribution. In addition, the major elements of pricing efficiency are given as timelines (rapidity of transmission) and accuracy (reliability) of price signals.

The competitive vertical market system in a static sense is defined as having instantaneous price adjustment. However, most real world markets are characterized by lead/lag and other forms of distortion as prices gravitate toward some long run equilibrium. Price adjustment may be initiated by a causal (lead) market level which results in prices in adjacent market levels reacting, possibly asymmetrically, through some distributed lag structure.

There have been a number of reasons offered as to how a lead position in the price transmission process is established. Ward (1982) and Ngenge (1982) imply a relationship between assimilation of market information and causality. Gupta and Mueller (1981) provide support for this contention by testing hypotheses of lead/lag structure in terms of market concentration and information. The major hypothesis is that concentrated market levels may have an advantage in assimilating market

information, which may in turn allow the more informed market level to lead other market levels in price formulation. On the other hand, Heien (1980) proposed that nonsystematic markup pricing rules were being utilized by retailers to take advantage of price signals originating from wholesalers and processors. Markup pricing rules would, in this case, put the retailer in a lag position. Thus, market structure and information availability may play an important role in the determination of lead/lag relationships which characterize the price transmission process between market levels.

The speed and extent with which price changes are passed to adjacent market levels may not be equivalent for price increases or decreases. Thus, the market may be characterized by asymmetry in price transmission. At the retail/wholesale interface, this asymmetry may be a function of (1) the cost of changing prices on current inventories, (2) the need to move certain product types quickly, or (3) simply the reluctance of retailers to relinquish a price peak once it is established. In addition, the desire to maintain most efficient use of capacity may result in retail price rigidity as wholesale prices vary. At the wholesale/producer interface, this asymmetry may not be as evident since atomistic producers are hypothesized to be price takers. However, if there exists monopsonistic pricing tendencies at the wholesale/producer level, wholesale price increases may not be passed to producers as strongly as price decreases.

CHAPTER III
EMPIRICAL METHODS

The study of price dynamics in a vertical market setting necessitates the investigation of the dynamic properties of price over time. This entails, first, the identification of the stochastic properties of the price series of concern in a non-economic sense and, secondly, the incorporation of these underlying stochastic properties in an explanatory economic model in order to test hypotheses regarding price determination processes. To accomplish the stated objectives of this study, price determination models must embody both economic theory and the empirically determined stochastic processes.

The analysis is initially concerned with making inferences regarding the stochastic properties characterizing observed price data through the use of time series methods. These stochastic characteristics are utilized to test hypotheses regarding lead/lag structures and the direction of price determination (causality) between interfacing market levels. Finally, the dynamic properties of price determination and the structural attributes of the market as suggested by theory are incorporated into an econometric model describing price at each market level. The analytical procedure outlined here will employ time series and regression (ordinary, two stage, and three stage least squares) methods.

Time Series Analysis

The objective of the time series analysis is to describe the underlying stochastic process that produces the original price series. These results can then be used to test hypotheses regarding the series of interest or forecast future values. A distinction regarding the resulting model is that the parameters determined are referred to in the literature as being "mechanically" derived, often considered devoid of theoretical economic content (Zellner, 1979). However, recent studies have supported the contention that time series models, in fact, are consistent with structural economic models (Anderson et al., 1983). In addition, the dynamic adjustment properties of price series data as revealed by time series analysis will allow testing of hypotheses originally motivated by the theory.

There exists two principal time series approaches: time domain (time series) analysis and frequency domain (spectral) analysis. The two are theoretically equivalent (Granger and Newbold, 1977). As Ngenge (1982) states, a result in one domain always has its equivalent result in the other domain. The spectral approach is particularly useful if the price series is suspected of being characterized by significant periodicity and if the nature of these periodic components are unknown. Price data for shrimp in the U.S. have empirically been found to not contain an identifiable cyclical component (Thompson and Roberts, 1983). Rather, periodicity is restricted to seasonal influences. Thus, the spectral approach would be inappropriate. This study primarily uses the more appropriate Box-Jenkins time domain approach, due to the nature of the data, access to and familiarity with established software and the relative ease of Box-Jenkins estimation (Box and Jenkins, 1976).

The two fundamental steps in time series analysis are (1) identification of the appropriate model and (2) estimation of parameters. The following discussions outline these two steps.

Univariate Time Series

An observed time series $(x_1,\ldots,x_t)$ may be considered a realization of some theoretical stochastic process (Granger and Newbold, 1977). In a general sense, the observed time series is selected from a finite set of jointly distributed random variables, such that there exists some probability distribution function $P(x_1,\ldots,x_t)$ that assigns probabilities to the possible combinations of normally distributed x_i, $i=1,\ldots,t$. Unfortunately, except for very small t, the probability functions of the outcomes $(x_1,\ldots,x_t)$ are not completely known. However, it is possible to generate a model that captures most of the underlying stochastic properties and, thus, the random behavior of the series.

Each time series possesses a unique characteristic—the autocorrelation function. This function, which is independent of the unit of measurement, indicates whether the process moves in the same or opposite direction through time. In other words, the autocorrelation function provides a measure of how much interdependence (memory) there is between data points in a given time series. The autocorrelation function is given as

$$\theta_x(L) = \frac{\gamma_x(L)}{\gamma_x(0)}.$$

where L is the number of lags, $\theta_x(L)$ is the autocorrelation, $\gamma_x(L)$ is the covariance between x_t and x_{t+L}, and $\gamma_x(0)$ is the variance of the stochastic process under the assumption of stationarity. The covariance of the series is given as

$$\gamma_x(L) = COV(x_t, x_{t+L}) = E[(x_t - E(x_t))(x_{t+L} - E(x_{t+L}))]$$

where $t = 0,1,2,...T$. The variance is given as

$$\gamma_x(0) = COV(x_t, x_{t+0}) = COV(x_t, x_t) = VAR(x_t)$$

Thus, $\theta_x(L)$ is defined as the autocorrelation at lag L.

The very strict assumption of stationarity of a time series implies that $\gamma_x(L)$ and $\gamma_x(0)$ are the same for all values of t. In fact, stationarity implies that the joint and conditional probability functions are invariant with respect to time. In particular, a stationary time series will be characterized by $-1 < \theta_x(L) < 1$ for $L > 0$. In addition, a time series characterized by

$$\theta_x(L) = \begin{cases} 0, \text{ where } L \neq 0 \\ 1, \; L = 0 \end{cases}$$

is called a white noise process. A white noise process is not autocorrelated and, thus, exhibits no interdependency (the series is serially uncorrelated). White noise is that part of a time series that cannot be explained by its own past.

As Pindyck and Rubinfeld (1981) note, most time series encountered in economic studies are not white noise processes and are non-stationary. However, these series can usually be differenced one or more times to obtain stationarity. The number of differences taken, d, is known as the order of homogeneity. A differenced series w_t is given as

$$w_t = (1-\beta)^d x_t$$

where β represents the difference operator where $\beta w_t = w_{t-1}$. A random walk process given as

$$x_t = x_{t-1} + \xi$$

is homogenous of order one (first differenced). In fact, x_t is stationary and white noise. If a series is white noise, it is also stationary, but the converse is not necessarily true.

Autoregressive (AR) Process

Many time series can be described as being an autoregressive process of order p such that x_t is expressed as a weighted average of past observations lagged p periods with a random disturbance on the end

$$x_t = \sum_{i=1}^{p} \phi_i x_{t-i} + R + \xi_t, \; t = 0,1,2,\ldots,T$$

where ϕ is the weight on each lagged x_t, ξ_t is the random disturbance, p is some maximum lag, and R is a constant term associated with the series mean and drift (R>0 when drift is present). Assuming R=0, this may also be written in backshift notation as

$$(1 - \phi_1 B - \ldots - \phi_p B^p)x_t = \xi_t$$

$$\phi(B)x_t = \xi_t$$

where $\phi(\beta) = (1-\phi_1\beta-\ldots-\phi_p\beta^p)$ and can be viewed as a polynomial of order p in lag operator B. The left-hand factor $\phi(\beta)$ acts as a filter on the time series x resulting in a white noise process ξ_t. Pindyck and Rubinfeld (1981) state that a necessary condition that x is stationary requires that the autoregressive process of order p be characterized by

$$\sum_{i=1}^{p} \phi_i < 1$$

The sufficient condition is that roots of the characteristic equation

$$\phi(B) = 0$$

lie outside the unit circle.

In addition, Fuller (1976) shows that when a time series is a stationary autoregressive process, the autocorrelation function $\theta_x(L)$ is a monotonically declining function of L that decays exponentially to zero. An autoregressive process possesses infinite memory where the current value of x_t depends on all past values.

Moving Average (MA) Process

Some time series can be defined as a moving average of order q where x_t is a weighted average of random disturbances lagged back q periods. This series x_t can be denoted as

$$x_t = \sum_{j=0}^{q} \beta_j \xi_{t-j} + S$$

where β_j is the weight on each lagged disturbance ξ_{t-j}, q is the maximum lag, and S is the mean of the process. Here we assume (as in the case of autoregressive model) that the random disturbance is generated by a white noise process. Thus, the mean S is invariant with t. In addition, by assuming stationarity, a moving average is characterized by

$$\sum_{i=1}^{q} \beta_i^2 < \infty$$

However, this is only a necessary condition. Rewriting x_t in backshift notation and letting S=0 yields

$$x_t = \beta(B)\xi_t$$

The invertibility condition requires that

$$\beta^{-1}(B)x_t = \xi_t$$

where $\beta^{-1}(B)$ must converge and the roots of the characteristic equation $\beta(B)$ be outside the unit circle.

A moving average process of order one (q=1) has a memory of only one period. In general, a moving average process of order q has a memory of exactly q periods and the autocorrelation function is given by

$$\theta_x(L) = \begin{cases} \dfrac{-\beta_L + \beta_1\beta_{L+1} + \cdots \beta_{q-L}\beta_q}{1 + \beta_1^2 + \beta_2^2 + \cdots + \beta_q^2} & , L = 1,\ldots,q \\ 0 \text{ (truncated)} & , L < q \end{cases}$$

Thus, the autocorrelation function for a moving average process has q non-zero values and is zero for lags greater than q. This can be contrasted to the exponentially decaying lags for an autoregressive process. There exists a relationship between moving average and autoregressive processes such that a finite order moving average process can be expressed as an infinite order autoregressive process. The converse is also true. In other words, an autoregressive process can be inverted into a pure moving average process and vice versa. This requires that certain invertibility conditions are met. In particular, the roots of the characteristic equations $\phi(\beta)$ and $\beta(B)$ must again all be outside the unit circle (Nelson, 1973).

Integrated Autoregressive Moving Average (ARIMA) Process

Many time series encountered are neither characterized by a pure moving average or pure autoregressive process. In addition, these time series are often non-stationary. Thus, time series such as these are

combinations of the above processes with a degree of homogeneity greater than zero. An ARIMA process of order (p,d,q), where p, d, and q are the order of the AR, difference, and MA components respectively, is given as

$$\sum_{i=0}^{p} \phi_i (1-B)^d \, x_{t-i} = R + \sum_{j=0}^{q} \beta_j \xi_{j-1}$$

For d=0, this can be expressed as

$$x_t - \phi_1 x_{t-1} - \phi_2 x_{t-2} - \ldots - \phi_p x_{t-p} = R + \xi_t - \beta_1 \xi_{t-1} - \beta_2 \xi_{t-1} - \ldots - \beta_q \xi_{t-q}$$

In backshift notation, this is written as

$$(1 - \phi_1 B - \phi_2 B^2 - \ldots - \phi_x B^p) x_t = R + (1 - \beta_1 B - \beta_2 B^2 - \ldots - \beta_q B^q) \xi_t$$

Finally, the above expressions, in differenced form, appear as

$$\phi(B)\, x_t = R + \beta(B)\, \xi_t$$

where $\phi(B)$ and $\beta(B)$ are converging invertible polynomials in the lag operator B. Since x_t has been differenced (is now homogeneous stationary), the process can be modeled using an AR of order p and an MA of order q. Thus, x_t is an integrated (I) ARMA, or an ARIMA (p,d,q) process.

Identification and Estimation of an ARIMA Model

The discussion above has shown that a homogenous nonstationary time series can be described as an ARIMA process of order p, d, and q. However, the correct specification of an ARIMA process necessitates selecting the proper values of p, d, and q to accurately describe the underlying stochastic process that generated the original time series. This task is accomplished by examining the autocorrelation function and partial autocorrelation function of the time series.

Identification of an ARIMA model begins with determining the degree of homogeneity in the time series. If the autocorrelative function $\theta_x(L)$ of the original data does not dampen quickly to zero, the data must be differenced d times until a stationary series results. This decision is made by visually observing $\theta_x(L)$ after each differencing to see if $\theta_x(L)$ dampens quickly. After determining the degree of homogeneity, the order of the autoregressive and moving average components must be specified. For the autoregressive component, this is done by examining $\theta_x(L)$ for oscillations. Examining the partial autocorrelations of the series provides a more definite estimation of the correct value of x. The partial autocorrelation function is derived from a set of linear equations given as

$$\theta_x(L) = \sum_{i=1}^{j} \tilde{\theta}_{ji}\,\theta_x(L - i), \qquad L = 1,\ldots,j,$$

which are known as the Yule-Walker equations (Pindyck and Rubinfeld, 1981). The partial autocorrelation of order j ($\tilde{\theta}_{jj}$) for an AR(p) is zero for j>1. Spikes in the partial autocorrelation function are indicative of significant autoregressive terms (p), whereas spikes in the autocorrelation function are indicative of significant moving average terms (q).

Once the ARIMA model has been specified as to the order of p, d, and q, the parameters are estimated. The Box-Jenkins estimation technique utilized in this study is discussed in detail by Nelson (1973). The procedure is of an iterative nature, requiring initial approximations of parameter estimates. These initial parameter values can be determined through solutions of the Yule-Walker equations.

After the ARIMA model has been identified and estimated, the model should be checked to determine if the specification is correct. The residuals (innovations) of an estimated ARIMA model are given as

$$\hat{\xi}_t = \phi(B)\beta^{-1}(B)x_t$$

If the model has been correctly specified, the residuals are white noise; i.e., the residuals are not dependent on their own past. Thus, the sample autocorrelation function of the residuals (r_t) given as

$$\hat{r}_k = \frac{\sum_t \hat{\xi}_t \hat{\xi}_{t-k}}{\sum_t \hat{\xi}_t^2}$$

would be approximately zero for lags (k) greater than zero. If the model is correctly specified, the residual autocorrelations are independent, normally distributed random variables with mean zero and variance 1/T, where T is the number of observations (Pindyck and Rubinfeld, 1981). A test is then performed using the statistic Q (Box and Pierce, 1970) given as

$$Q = T \sum_{k=1}^{K} \hat{r}_k^2$$

for the first K residual autocorrelations. The Q statistic is distributed as chi square with K-p-q degrees of freedom. If Q is greater than the tabulated critical value, the hypothesis that the residuals are white noise is rejected. In this case, an alternative ARIMA model is selected and the procedure repeated.

Direction of Price Determination-Causality

The empirical model must be properly specified with respect to the appropriate cause and effect relationship as suggested by knowledge of the market and as dictated by the theory. Correct specification is vital to obtaining valid parameter estimates. Misspecification is trivial only if R^2 is equal to one (Pindyck and Rubinfeld, 1981). However, theory can only suggest the nature of the cause and effect relationship. Often necessary a priori information is not available to properly specify the direction of causality; e.g., between prices, in the market place, thus avoiding misspecification and providing consistent and efficient parameter estimates.

A causality relationship between two time series of data, Y and X, can be defined in the Granger sense (Granger, 1969, page 428) where "Y_t is causing X_t if we are better able to predict X_t using all available information, than if the information apart from Y_t had been used." The rather cumbersome restriction of using all available information can be avoided as Shonkwiler and Spreen (1982) suggest by saying Y_t causes X_t when Y_t can improve the predictions of X_t compared to the prediction of X_t taking into account the past history of X_t alone. In this sense, Granger (1969) and Bishop (1979) give four basic definitions of interdependency of a bivariate series as

(1) Unidirectional causality — Y_t causes X_t or X_t causes Y_t when using past information on X_t and Y_t

(2) Bi-directional feedback — Y_t causes X_t and X_t causes Y_t,

(3) Instantaneous causality — Y_t causes X_t where current X is better predicted by including current Y, or

X_t causes Y_t where current Y is better predicts by including current X, and

(4) No causality.

Pierce (1977) discusses other causal patterns and these will be mentioned later. Each time series X_t and Y_t is assumed stationary. Though the above definitions are not in testable form, definition (1) implies a recursive relationship between X_t and Y_t, while (3) implies simultaneity. The "strength" of causality and the existence of a lead/lag relationship lose any meaning if (2) exists (Bishop, 1979). Testable forms of these definitions regarding the null hypothesis of no causality are given below.

Granger Method

The Granger test for unidirectional and instantaneous causality between two stationary time series X_t and Y_t involves the estimation via ordinary least squares of a four-equation regression model given as

$$\text{A.1} \quad X_t = \sum_{j=1}^{n} a_i X_{t-j} + \sum_{i=1}^{n} c_i Y_{t-i} + u_t^1$$

$$\text{A.2} \quad X_t = \sum_{j=1}^{n} a_j X_{t-j} + u_t^2$$

$$\text{B.1} \quad Y_t = \sum_{j=1}^{n} b_j Y_{t-j} + \sum_{i=1}^{n} d_i X_{t-i} + v_t^1$$

$$\text{B.2} \quad Y_t = \sum_{j=1}^{n} b_j Y_{t-j} + v_t^2$$

where n is the maximum number of lags used. To test the null hypothesis that Y does not cause X, an F-test is performed using the residuals from A.1 and A.2 to see if the c_i are different from zero. The F statistic with q and T-t degrees of freedom is defined as

$$F_{q,T-t} = \frac{(ESS_r - ESS_u)/(q)}{(ESS_u)/(T-t)}$$

where t is the number of parameters estimated in the unrestricted model (A.1), q is the number of parameters estimated in the restricted model (A.2), T is total number of observations, and ESS_r and ESS_u are error sums of squares for the restricted and unrestricted model, respectively. If the F statistic for A.1 and A.2 is significant then the null hypothesis is rejected, suggesting that Y causes X. A test of the d_i can be performed testing causality in the opposite direction to support this result (Colclough and Lange, 1982) or check for the existence of feedback. To check for either instantaneous or unidirectional causality, the index i in equations A.1 and B.1 is initialized to zero. The present study, however, will use the Granger method to test hypotheses regarding strictly unidirectional causality. These tests assume the error terms are uncorrelated white noise, such that $E(u_t u_s) = E(v_t v_s) = 0$ for $s \neq t$, for every t and s. Rejecting the null hypothesis that Y does not cause X suggests that X should be specified as some function of lagged Y.

Sims Method

Another method of testing for unidirectional causality has been proposed by Sims (1972) where the test involves a system of two regression equations

$$X_t = \sum_{j=-n}^{n} a_j Y_{t-j} + e_t^1$$

$$X_t = \sum_{j=0}^{n} b_j Y_{t-j} + e_t^2$$

In this case, a test of the hypothesis that X does not cause Y is

performed by testing if the coefficients on future Y are not significantly different from zero. This procedure involves an F-test defined as for the Granger test which uses errors from both regressions, the second regression not including future (lead) Y ($-1 > j > -n$). The variables can be reversed and the test repeated to check for causality in the opposite direction or feedback. The series are assumed to be stationary with white noise error. Filtering the X and Y series may be necessary to achieve stationarity. If the residuals are not white noise, the causality tests are invalid (Granger and Newbold, 1977).

Haugh-Pierce Method

The Haugh (1972) and Pierce (1977) method makes use of the techniques of determining residual cross correlation to infer causality between two time series X and Y. Assume initially that two time series, X_t and Y_t, can be represented by

$$G(B)\, X_t = u_t$$

$$F(B)\, Y_t = v_t$$

where F(B) and G(B) are converging invertible polynomial filters in the lag operator B (backshift notation) and the innovations v_t and u_t being white noise processes which are uncorrelated with themselves. The cross correlation between the innovations at lag k is given as

$$r_{uv}(k) = \frac{E(u_{t-k}, v_t)}{[E(u_t)^2 E(v_t)^2]^{1/2}}$$

Since u and v are not observed, the estimated value of the innovations are utilized resulting in the sample cross correlations $r_{\hat{u}\hat{v}}(k)$, which Haugh has shown are asymptotically normal independently distributed with zero mean and standard deviation of $T^{-1/2}$, where T is the total number of observations. Each $r_{\hat{u}\hat{v}}(k)$ can be individually tested for significance where

$$r_{\hat{u}\hat{v}}(k) > 2T^{-1/2}$$

implies a significant cross correlation. Pierce (1977) lists alternative conditions of significance found in residual cross correlations and the corresponding causality inference as

(1) $r_{uv}(k) \neq 0$ for some $k>0$ implies X causes Y,

(2) $r_{uv}(k) \neq 0$ for some $k<0$ implies Y causes X,

(3) $r_{uv}(0) \neq 0$ implies instantaneous causality,

(4) $r_{uv}(k) \neq 0$ for some $k>0$ and some $k<0$ implies feedback,

(5) $r_{uv}(k) = 0$ for all $k<0$ implies Y does not cause X,

(6) $r_{uv}(k) = 0$ for some $k>0$ and $r_{uv}(k) = 0$ for all $k<0$ implies unidirectional causality from X to Y,

(7) $r_{uv}(k) \neq 0$ for all $k \neq 0$ and $r_{uv}(k) \neq 0$ implies X and Y are related only instantaneously, and

(8) $r_{uv}(k) = 0$ for all k implies X and Y are independent.

This study adopts the definitions of instantaneous and unidirectional causality and feedback as shown above. These notions of causal inference from residual cross correlations have been utilized by several recent studies (Bessler and Schrader, 1980a; Bessler and Schrader, 1980b; Miller, 1980; Shonkwiler and Spreen, 1982; Spreen and Shonkwiler,

1981). Haugh and Pierce suggest that the absence of unidirectional causality from X to Y can be tested using

$$T \sum_{k=1}^{m} [r_{\hat{u}\hat{v}}(k)]^2 > \chi_m^2(\alpha)$$

where m (degree of freedom) is the maximum lag period. If the expression is true, then we reject the null hypothesis that X does not cause Y. Similarly, the null hypothesis that X and Y are unrelated would not be rejected at the α level if and only if

$$T \sum_{k=-m}^{-m} [r_{\hat{u}\hat{v}}(k)]^2 < \chi_{2m+1}^2(\alpha)$$

The chi-square distributed statistic $T \ \Sigma[r_{\hat{u}\hat{v}}(k)]^2$ will hereafter be referred to as the Haugh-Pierce statistic.

The data are used to discern the nature of price determination complementing a priori knowledge of the market. These causality results provide a more definitive basis for model specification. This study proceeds with the Haugh-Pierce notion of causality.

Dynamic Regression Methods

The dynamic regression approach is a technique which utilizes the underlying dynamic and causal properties of a time series. The final result of the analysis—the transfer function—provides a comprehensive model of the dynamic relationship between time series; e.g., two price series. In particular, the development of a bivariate transfer function in terms of prices in adjacent market levels utilizes the time series ARIMA filters for each series and the causal relationship between the innovations of each series to construct a distributed lag or impulse

response model which embodies the dynamic nature of the relationship exhibited by the two time series.

Haugh and Box (1977) outline the dynamic regression procedure as a two-step process which identifies (1) the relationship between two series by characterizing the univariate models of each time series and (2) the relationship between the two univariate innovation series. The innovation series are each assumed a white noise process and are considered the "driving force" of the original series. Shonkwiler and Spreen (1982) provide a more detailed outline of the dynamic regression procedure, which would be to

(1) identify and estimate univariate time series or filter models for each series of interest via Box-Jenkins methodology,

(2) use the innovation series of the filtered series to determine the properties of causality between the series via Haugh and Pierce notions of causality,

(3) identify a "dynamic shock" model that expresses the relationship between the innovation series given the causal pattern from (2) via Haugh and Box methodology, and

(4) derive an "impulse response" or distributed lag model utilizing knowledge of the original univariate filter models and the dynamic shock models via Haugh and Box methodology. This final specification is referred to as the transfer function.

<u>Filter Models</u>

The filters are determined by applying time series methods to the original time series; e.g., X_t and Y_t, as discussed earlier in this chapter. Stationary time series u_t and v_t are obtained which can be represented by

$$\theta(B)X_t = u_t$$

$$\phi(B)Y_t = v_t$$

where $\theta(B)$ and $\phi(B)$ are invertible polynomials in the lag operator B. The terms u_t and v_t represent the white noise processes (innovations) obtained from of X and Y, respectively. The polynomials $\theta(\beta)$ and $\phi(\beta)$ may be viewed as filters which are identified and estimated by using the Box-Jenkins approach. The sample cross correlations between u_t and v_t $\{r_{\hat{u}\hat{v}}(k)\}$ provide a means by which the properties of interdependency (causality) between X and Y can be assessed. In addition, tests of unidirectional causality can be performed using the chi-square Haugh-Pierce statistic. These inferences regarding the direction of price determination are vital for specification of the transfer function.

Dynamic Shock Model

Having determined a lead/lag structure; e.g. X_t leads Y_t, Haugh and Box (1977) show that it is possible to express Y_t as a distributed lag on X_t as

$$Y_t = \delta(B)X_t + a_t$$

where $\delta(B)$ is some polynomial of X_t and a_t is an error process. The weights on the terms of the polynomial $\delta(B)$ are referred to as the impulse response parameters. These parameters characterize the response of Y_t to changes in the "input" X_t, net of the "masking effect" of the stationary white noise process a_t. To identify the order of the polynomial $\delta(B)$ connecting Y_t and X_t, a model must first be identified that connects the innovations u_t and v_t. This procedure will make use of the sample residual cross correlations $r_{\hat{u}\hat{v}}(k)$, where k is the order of lag, to arrive at a dynamic shock model given as

$$v_t = V(B)u_t + \Psi(B)a_t$$

where v_t and u_t are the white noise processes of filtered Y and X series, respectively, a_t is the dynamic shock model error process, and V(B) and Ψ(B) are polynomials of the lag operator B. Since by definition u_t and v_t are orthogonal to themselves; e.g., $COV(u_t,u_s) = 0$, for every $t \neq s$, then each parameter coefficient in V(B) is simply the bivariate regression coefficient relating v_t to u_{t-k} given as

$$V_k = \frac{\sigma_{v_t}}{\sigma_{u_t}} r_{uv}^{\hat{}\hat{}}(k)$$

where σ_{v_t} and σ_{u_t} are the standard error of the innovation series and k is the lag of the residual cross correlation.

Dynamic Regression Transfer Function

Given that the parameter coefficients of V(B) have been identified and the order of the polynomial is known, the original filter expressions

$$\theta(B)X_t = u_t$$

$$\phi(B)Y_t = v_t$$

are substituted into the dynamic shock model (Haugh and Box, 1977) to give

$$\phi(B)Y_t = V(B)\theta(B)X_t + \Psi(B)a_t$$

and isolating Y_t yields the impulse response or transfer function

$$Y_t = \phi(B)^{-1}V(B)\theta(B)X_t + \phi(B)^{-1}\Psi(B)a_t$$

Completing the necessary multiplication and division of the polynomials shown above, a distributed lag function emerges which expresses Y_t as a function of current and/or lagged X_t and is expressed as

$$Y_t = \delta(B)X_t + \lambda(B)a_t$$

These polynomials are of interest in that they explicitly show the lead/lag structure between time series X and Y as revealed by the data. Depending on the nature of $\lambda(\beta)$, the parameters of $\delta(B)$ and $\lambda(B)$ may be estimated using ordinary least squares, non-linear least squares, or maximum likelihood techniques.

The transfer function embodies the causal properties and lead/lag structure between X and Y and provides the basis from which to determine the speed and magnitude with which change in X is reflected in Y, given the specification above. In addition, the structural characteristics of the relationship between X and Y have been supported by giving the data a chance to "speak" of relationships that do or do not exist, complementing expectations based on theory and minimizing the probability of misspecification.

Once the transfer function relating X and Y has been identified, the lead/lag structure; e.g., current and/or lagged prices, are included in a more complete explanatory model of the market. The regression methods that are employed to estimate the econometric model of prices are discussed below.

General Regression Methods

The analysis of time series properties, causality tests, and derivation of the transfer function provides a set of expressions in terms of endogenous and lagged endogenous variables. These expressions evolve into a more comprehensive model when they are augmented with additional exogenous variables whose presence is dictated by theory and knowledge of the market. This study strives to generate such models describing price at each of three market levels.

The method of analysis that was utilized in estimating the proposed model is linear regression. The use of ordinary, two stage, or three stage least squares regression is conditional on the analysis of the direction of price determination and the error structures of the estimated expressions. A detailed discussion of regression technique and methods can be found in Kmenta (1971) or Theil (1971).

If the analysis of the direction of price determination infers recursiveness, single equation methods such as ordinary least squares (OLS) may be an appropriate tool for estimation. However, if simultaneity is implied, a simultaneous system estimation approach, such as two stage (2SLS) or three stage (3SLS) least squares, is required. Both methods provide insight into relationships which exist within the structure of the market system. The initial estimates obtained from single equation methods or systems methods are referred to as structural estimates. These estimates for each equation relate a unique set of predetermined and endogenous variables to a given endogenous variable. Each equation describes a part of the structure of the market (Theil, 1971). The estimates obtained can provide further insights into the market through the derivation of reduced and final form parameter estimates. The reduced form of the model expresses each endogenous variable of the model in terms of only exogenous variables. A reduced form estimate provides a clearer interpretation of the relationships between endogenous and predetermined variables since the impact of a predetermined variable on each endogenous variable has now been isolated. Further, Kmenta (1971) states that the reduced form shows explicitly how the endogenous variables are jointly dependent on the predetermined variables and the disturbances of the model.

A system of g expressions in terms of g endogenous and k predetermined variables can be written in matrix notation for each observation as

$$\Gamma Y_t + BX_t = E_t$$

where Y is a g×l vector of endogenous variables, X is a k×l vector of predetermined variable, Γ is a g×g matrix of endogenous variable coefficients, B is a k×k matrix of predetermined variable coefficients, and E is a g×l vector of disturbance terms. Once the system of g equations has been estimated, it can be expressed in reduced form as

$$Y_t = -\Gamma^{-1}BX_t + \Gamma^{-1}E_t \quad \text{or}$$

$$Y_t = \pi X_t + V$$

where π is a g×k matrix of derived reduced form estimates and V is a g×l vector of disturbances. The elements of π, which include exogenous and, possibly, lagged endogenous variable coefficients, are referred to as impact multipliers (Goldberger, 1964). The impact multiplier measures the immediate effect of a change in the predetermined variable on the endogenous variable after all interdependencies have been accounted for in the same time period. If the matrix π includes lagged endogenous variables, estimates can be derived that measure the total effect of changes that may take one or more time periods (suggested by the presence of lagged terms) to work through the market. These parameters are referred to as total multipliers and are derived from the final form of the matrix of reduced form estimates. Thus, in the presence of lagged endogenous variables, the reduced form estimates represent an intermediate step.

The reduced form matrix π can be partitioned into submatrices such that

$$Y_t = d_0 + D_1 Y_{t-1} + D_2 X_t + \xi_t$$

where Y_t is a $g \times 1$ vector of endogenous variables, Y_{t-1} is a $g \times 1$ vector of endogenous variables lagged one period, X_t is a $k \times 1$ vector of the exogenous variables, d_0 is a vector of constant terms, D_1 is a $g \times g$ matrix of derived reduced form estimates for the lagged endogenous variables, D_2 is a $g \times k$ matrix of derived reduced form estimates for the exogenous variables, and ξ_t is a $g \times 1$ vector of disturbances. The elements in D_1 and D_2 are impact multipliers. For the sake of simplicity, no lagged exogenous variables are included in this discussion and the endogenous variables are only lagged one period. To obtain a final form expression for the system, Y_t must be expressed in a form free of lagged endogenous variables. The expression Y_t lagged one period and substituted back into Y_t gives

$$Y_t = (D_1 d_0 d_0) + D_1^2 Y_{t-2} + D_1 D_2 X_{t-1} + D_2 X_t + D_1 \xi_{t-1} + \xi_t$$

Repeating this procedure s times yields

$$Y_t = \sum_{i=1}^{s} D_1^i d_0 + D_1^s Y_{t-s} + \sum_{i=0}^{s} D_1^i D_2 X_{t-s} + \sum_{i=0}^{s} D_1 \xi_{t-i}$$

However, note that if

$$\lim_{s \to \infty} D_1^s = 0,$$

then

$$\lim_{s \to \infty} \sum_{i=0}^{s} D_1^i = (I - D_1)^{-1}.$$

Then by dropping the time subscript, Y_t can be written as

$$Y = D + \hat{X}X + E$$

where $D = (I - D_1)^{-1}d_0$

$\hat{X} = (I - D_1)^{-1}D_2$, and

$E = (I - D_1)^{-1}\xi$

The elements of D, $\hat{X}$, and E are referred to as the final form estimates of the model.

CHAPTER IV
EMPIRICAL MODELS

Introduction

The theoretical economic model of a system of price dependent demands for the major market levels in the domestic shrimp marketing system was developed in Chapter II. The empirical form of the model is presented in this chapter. Initially, the price dependent demands are re-introduced in implicit form and allied with specific sectors of the domestic shrimp market system. A general discussion of the data utilized by the analysis is given. Explicit asymmetric price dependent demand expressions, with specific data needs are discussed for three market levels on a monthly and quarterly basis. In addition, expressions for the margin between levels are derived. Finally the estimation procedures are summarized.

Implicit Models

A general representation of the structural price equations developed in Chapter II are given implicitly as

(30) $p^r = f_1(M_1;\ Q_D^C,\ D)$

(31) $p^w = f_2(M_2;\ c^r,\ Q_D^R)$

(32) $p^f = f_3(M_3;\ c^w,\ Q_D^W)$

(33) $p^p = f_4(M_4;\ c^f,\ Q_D^F)$

where p^r, p^w, p^f, and p^p represent prices received by retailers, wholesalers, first handlers, and producers, respectively. M_i represents a set of input prices consisting of subsets of current and lagged endogenous and exogenous prices, D is a set of retail demand shifters, Q_D^C, Q_D^R, Q_D^W, and Q_D^F are the quantities offered by retailers, wholesalers, first handlers, and producers, respectively, and c^r, c^w, and c^f are costs associated with offering the product to consumers, retailers, and wholesalers, respectively.

Each price expression coincides with demand at a given market level of the domestic market system. An illustrative schematic of this system of market channels is presented in Figure 6. The schematic is divided into four sectors. Each sector represents a market level characterized by a given demand expression, with sector A, B, C, and D associated with demand p^r, p^w, p^f, and p^p, respectively. Thus, each demand represents the price determination process that exists in a given sector of the market system for fresh-frozen, raw-headless shrimp product.

The final specification of the price dependent demand model is constrained by available data. The objectives of this study require inferences to be made regarding price determination on a size class basis. Estimation of the full set of demand models represented by equations (10), (12), (14) and (16) given in Chapter II is impossible due to the lack of data by size class necessary to specify each demand expression (data will be discussed in detail later in this chapter). Thus, data availability placed restrictions on which of the expressions

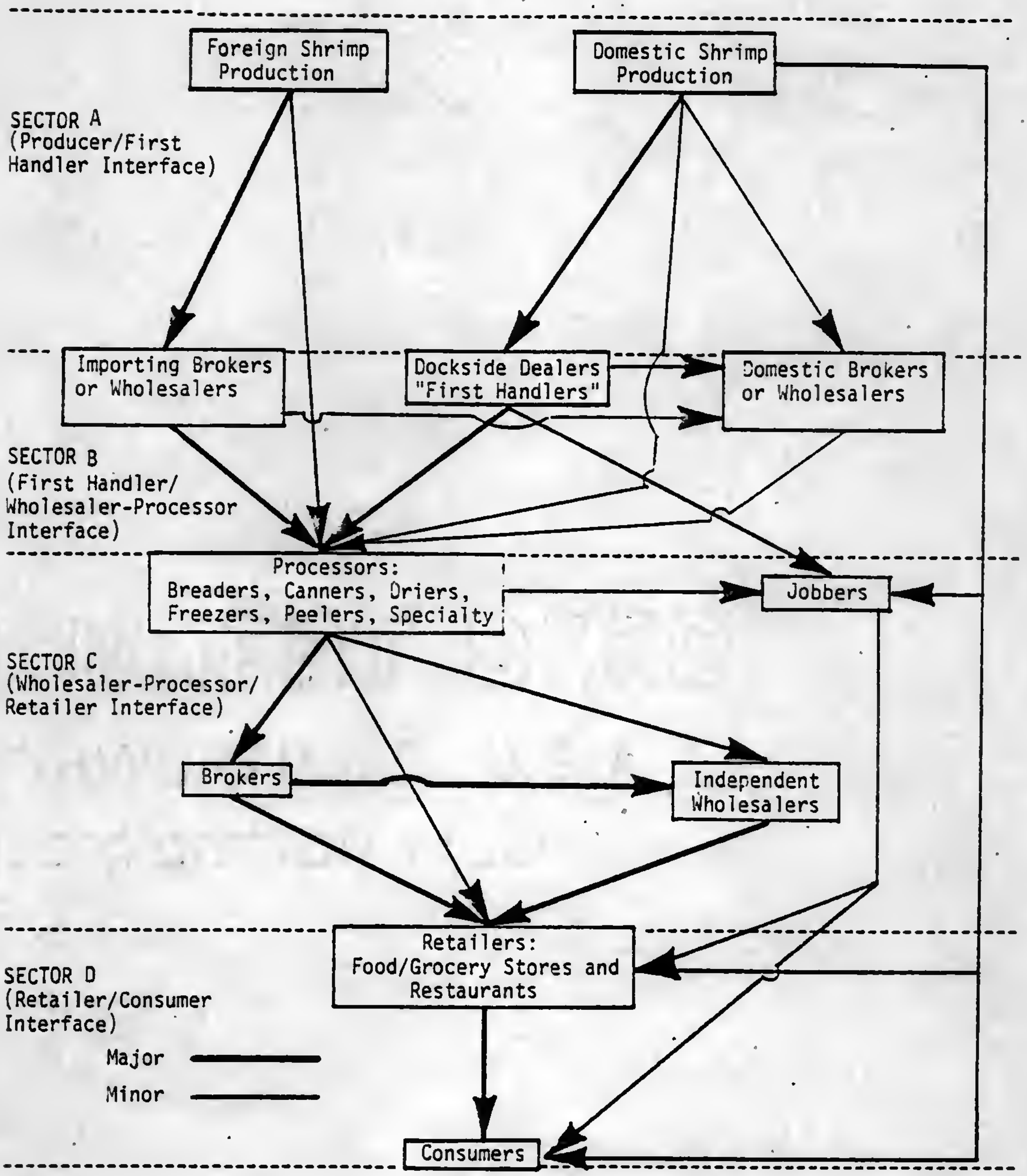

Figure 6. Market Channel Schematic Representation for the U.S Shrimp Market System.

represented by equations (30) through (33) could be estimated. Price data is not available to describe the transaction between the first handlers and the wholesaler/processor (region B is Figure 6). Thus, only expressions (30), (31), and (33) are modeled on a monthly and quarterly basis for two size classes of fresh-frozen, raw-headless shrimp product. Supply models were not estimated due to the assumption that supply of raw product is exogenous and inelastic with respect to price.

Symmetric and Asymmetric Models

Price models often hypothesize that increases and decreases in price at one level are passed on equally to adjacent levels (Heien, 1980). The question here is not one of demand irreversibility, such as habit formation with a given good or its competitors. Rather, the question is one of asymmetry in price transmission between adjacent market levels. The possible reasons for asymmetric price response have been discussed in Chapter II. Once the direction of price causality between adjacent market levels has been determined, the question of asymmetry in price transmission can be addressed. Asymmetric tests are restricted to recursive models. The methodology for dealing with the inherent endogenous nature of asymmetric variables in a simultaneous framework is not developed in this study. Only if causality between the prices of adjacent market levels is found to be unidirectional will asymmetric models be tested.

A price equation, assuming the direction of price causality is upward through the market system, may be given as

(1) $R_t = \alpha_0 + \alpha_1 W_t + \xi_t$

when R_t is retail price, W_t is wholesale price, and ξ_t is the error term. This simple model assumes symmetric retail price response to changes in wholesale price regardless of whether wholesale price increases or decreases. An alternative Wolffram-form price equation (Young, 1980) would allow for asymmetric price response and is given as

(2) $R_t = \alpha_0 + \alpha_1 WI_t + \alpha_2 WD_t + \xi_t, \ t = 1,\ldots,N$

where

$$WI_t = \sum_{i=0}^{t} (W_{t-i} - W_{t-i-1}) \, DI_{t-i}$$

$$WD_t = \sum_{i=0}^{t} (W_{t-i} - W_{t-i-1}) \, DD_{t-i}$$

$$DI_{t-i} = \begin{cases} 1, & W_{t-i} > W_{t-i-1} \\ 0, & \text{otherwise} \end{cases}$$

$$DD_{t-i} = \begin{cases} 1, & W_{t-i} < W_{t-i-1} \\ 0, & \text{otherwise} \end{cases}$$

where WI_t and WD_t represent cumulative wholesale price increases and decreases, respectively. Thus, testing the significance of α_1 and α_2 is a test of the significance of the effect of a wholesale price increase and decrease, respectively. Gollnick (1972) suggests a convenient rearrangement of equation (2) such that

$$W_t = W_0 + WI_t + WD_t \text{ (Identity)}$$

$$WI_t = W_t - W_0 - WD_t$$

where W_0 equals W_t for t=0. Substituting for WI_t gives

$$R_t = \alpha_0 + \alpha_1 (W_t - W_0 - WD_t) + \alpha_2 WD_t + \xi_t$$

which yields

$$R_t = \alpha_0^* + \alpha_1 W_t + \alpha_2^* WD_t + \xi_t$$

where $\alpha_0^* = (\alpha_0 - \alpha_1 W_0)$ and $\alpha_2^* = (\alpha_2 - \alpha_1)$. A test of significance of $(\alpha_2 - \alpha_1)$ provides a direct test of asymmetry. Recall that α_1 measures the reaction of R_t when W_t increases and α_2 measures the reaction of R_t when W_t decreases. The significance of α_2 can be measured via the estimate α_2^* by writing

$$\alpha_2^* = \alpha_2 - \alpha_1$$

$$\alpha_2 = \alpha_2^* + \alpha_1$$

and $\text{var}(\alpha_2) = \text{var}(\alpha_2^* + \alpha_1) = \text{var}(\alpha_1) + \text{var}(\alpha_2^*) + 2\ \text{Cov}(\alpha_1, \alpha_2^*)$.

The t-statistic would then be written as

$$t = \frac{(\alpha_2^* + \hat{\alpha}_1) - 0}{\sqrt{\text{VAR}\ (\alpha_2)}} = \frac{\alpha_2^* + \hat{\alpha}_1}{\text{Var}\ \alpha_1 + \text{Var}\ \hat{\alpha}_2^* + 2\ \text{Cov}\ (\alpha_1, \hat{\alpha}_2^*)}$$

where $\hat{\alpha}_2^*$ is the estimate of α_2^*. If in the event that α_2^* is found to be insignificant, the test of significance on the coefficient α_1 reverts to a symmetric test of retail price response to increases or decreases in wholesale price. Expressions for p^r, p^w, and p^p can now be written in explicit form.

Data

The estimation of time series properties and analysis of causal relationships of prices for shell-on, fresh-frozen, raw-headless shrimp (hence forth referred to simply as raw-headless) at retail, wholesale,

and ex-vessel market levels was accomplished for the years 1968-1981. Monthly and quarterly price models were estimated with data from 1972-1982. The analyses were oriented toward two size classes—the 31-40 and 21-25 tails per pound ("count") sizes classes of shell-on, fresh-frozen, raw-headless shrimp. The size class price and quantity data at each market level relate to these specific size class, with one exception. Retail price data are not reported for the 31-40 size class. Retail prices are given, however, for the 36-42 size classes. Though the 36-42 size class represents a smaller shrimp than the 31-40 size class, this study circumvents this data inconsistency by assuming the prices for the 36-42 and 31-40 size classes are not significantly different. For the sake of notational simplicity, the discussions henceforth will refer only to the 31-40 and 21-25 size classes. However, the reader should bear in mind the discrepancy at the retail. level.

Monthly prices, aggregate beginning inventories, aggregate landings, and aggregate import data were obtained from the Shellfish Market Review published by the National Marine Fisheries Service (NMFS). Monthly cost index data were obtained from the Agricultural Outlook published by the U.S.D.A. and unpublished U.S.D.A. files. Monthly income and consumer price index data were obtained from reports published by the Bureau of Economic Analysis and the Bureau of Labor Statistics, respectively. Monthly landings and import data on a size class basis were obtained from unpublished NMFS data tapes. Though 168 monthly observations were available for the time series and causality analysis, the estimation of price models were restricted to only 120 observations due to data limitations on monthly landings and import data by size class.

The quarterly observations were constructed from the published secondary monthly data. Quarterly price, income, and index data were constructed as unweighted three-month averages of the monthly data. To obtain the quarterly price data, the monthly price series were simply averaged over three-month periods for the years 1972 through 1981. An attempt was made to use a weighted average for the ex-vessel series, however, no significant gain was made relative to a three-month average (the three-month average explained 99 percent of the variation in the weighted average). Because of this, and since no reliable quantity variable was available to properly weight the wholesale and retail levels, a simple three-month average was used for all three quarterly price series. Quarterly consumption, landings, and import data were constructed as unweighted totals over the same three month intervals. Beginning inventories on a quarterly basis, however, represent inventories at the beginning of the first month of each quarter.

Statistical Models

The exact specification of the monthly and quarterly price models is conditional on the outcome of the first and second objectives as outlined in Chapter I. The causality analysis will determine the direction of price determination and, thus, what prices make up the subsets of M_i (equations 30 through 33) found in each price model.

The causality analysis must be completed before the system of price models can be specified in terms of current and lagged exogenous and endogenous prices. The following discussion of the price models ignores the specification of M_i found in each model and discusses the variables which are given to be predetermined. A discussion of the final

specification of each model is given in Appendix B. Excluding consideration of the prices found in M_i for each model and the definition of certain quantity variables, the price models for the 31-40 and 21-25 size class are identical relative to the predetermined variables discussed below. All price models are over identified. Price and quantity variables are in heads-off units.

Retail Price Models

The monthly retail price model for 36-42 and 21-25 count raw-headless shrimp is given as

$$R_t = \alpha_0^r + \sum_{i=1}^{NR} \beta_i^r [M_i^r] + \alpha_1^r RDY_t + \alpha_2^r TCFF_t + \alpha_3^r CPI_t + \xi_1$$

where R_t = retail (non-institutional) price in time period t (Shellfish Market Review, NMFS)

RDY_t = aggregate real disposable income in billions of dollars (base year = 1972)(Bureau of Economic Analysis),

$TCFF_t$ = Business Statistics: 1982, total retail supply (disappearances from wholesale market) of all sizes raw-headless shrimp in millions of pounds (Shellfish Market Review, NMFS),

CPI_t = consumer price index for meat and poultry products, deseasonalized with 1972 = 100 (CPI Detailed Report, Bureau of Labor Statistics),

NR = number of current and lagged endogenous and exogenous prices found in M_i^r for each size class model, where i refers to size class,

and α_i^r and β_i^r are the coefficients to be estimated, with the superscript r referring to the retail model. Each β_i^r is associated with a current

or lagged exogenous or endogenous price contained in M_1^r. M_3^R and M_2^R refer to a set of prices for the 36-42 and 21-25 size class, respectively. The model is the same for each size class, varying only by the dependent price. Thus, only one model is discussed.

The retail price expression represents the demand by consumers for the retail product and corresponds to equation (30). The retail price data represents grocery and food store prices for raw-headless shrimp in the Baltimore, Maryland area as reported by the National Marine Fisheries Service (NMFS). The model was specified as a function of quantities moving through the retail market and parameters which may capture shifts in retail demand - income and prices of competing meat products. As income increases, demand for shrimp should increase, thereby bidding up the price of shrimp. Similarly, as the price of competing products increases consumers may consume more shrimp products, also bidding up the price of shrimp. In this sense α_1^r and α_3^r are hypothesized to have positive signs. The consumption, or retail supply, of shrimp product should be indirectly related to price. This assumption should hold true even though $TCFF_t$ is aggregate in nature and $TCFF_t$ may pick up some substitution effects between other size classes and a very specific size class. Thus, α_2^r is anticipated to have a negative sign.

The presence of β_1^r associated with a wholesale price allows for a price determination process between retail and wholesale price which is characterized by recursivity or simultaneity. The signs on current and lagged β_1^r are anticipated to be positive, reflecting a direct positive relationship between contemporaneous and lagged price movements at the wholesale and retail level.

The specification of the model is the same for monthly or quarterly data. The prices found in M_i^r for each size class may differ for monthly and quarterly data as the price determination process evolves over a longer sampling internal since the data has been condensed into three-month quarters. In the quarterly model all price parameters in M_i^r, RDY_t, and CPI_t represent unweighted 3-month averages of the monthly data. The parameter $TCFF_t$ now represents a three-month total for retail supply of all sizes of raw-headless shrimp. The variables for monthly models are defined as above but represent the secondary data (monthly) as published by the various data reporting agencies.

<u>Wholesale Price Models</u>

The monthly wholesale price model for 31-40 count raw-headless shrimp is given as

$$W_t^3 = \alpha_0^w + \sum_{i=1}^{NW} \delta_i^w [M_3^w] + \alpha_1^w \, BSFF_t + \alpha_2^w \, OI_t^3 + \alpha_3^w \, I31_t + \alpha_4^w \, TMCI_t + \xi_2'$$

and for 21-25 count raw-headless shrimp is given as

$$W_t^2 = b_0^w + \sum_{i=1}^{NW} \beta_i^w [M_2^w] + b_1^w \, BSFF_t + b_2^w \, OI_t^2 + b_3^w \, I21_t + b_4^w \, TMCI_t + \xi_2''$$

where

W_t^3 = wholesale price for 31-40 size class (<u>Shellfish Market Review</u>, NMFS),

W_t^2 = wholesale price for 21-25 size class (<u>Shellfish Market Review</u>, NMFS),

$BSFF_t$ = beginning inventories of raw-headless shrimp in millions of pounds (<u>Shellfish Market Review</u>, NMFS),

OI_t^3 = total imports of raw-headless shrimp of all size classes (Shellfish Market Review, NMFS), excluding the 31-40 size class imports in millions of pounds,

OI_t^2 = total imports of raw-headless shrimp of all size classes (Shellfish Market Review, NMFS), excluding the 21-25 size class imports in millions of pounds,

$I31_t$ = imports of raw-headless shrimp of 31-40 size class at selected ports of entry in millions of pounds (NMFS unpublished files),

$I21_t$ = imports of raw-headless shrimp of 21-25 size class at selected ports of entry in millions of pounds (NMFS unpublished files),

$TMCI_t$ = intermediate food marketing cost index, 1967=100 (Agricultural Outlook, USDA and unpublished USDA files),

NW = number of current and lagged endogenous and exogenous prices found in M_i^W for each size class model, where i refers to size class,

and a_i^W, δ_i^W, b_i^W, and β_i^W are the coefficients to be estimated. Each δ_i^W and β_i^W is associated with a current or lagged endogenous or exogenous price contained in M_3^W and M_2^W, respectively.

The wholesale price expression represents the demand by retailers for wholesale product, which corresponds to equation (31). The wholesale price data represents ex-warehouse prices in the New York metropolitan area for boxed and branded raw-headless brown shrimp as reported by the NMFS for the New York Fulton Fish Market. Wholesale price was specified as a function of quantities moving through the wholesale market and costs (input prices) representing the retail/wholesale price

spread (costs incurred by the retailers). The quantity variable Q_D^R found in expression (31) has been separated into component quantities--inventories and imports. Wholesale price is assumed to be inversely related to the quantity demanded and moving through the wholesale level. Thus, the coefficients α_1^W, α_2^W, α_3^W, b_1^W, b_2^W, and b_3^W are anticipated to be negative in sign. The parameter OI_t and $I31_t$ for the 31-40 size class model and OI_t and $I21_t$ for the 21-25 size class model were included in an attempt to measure the relative impact of "own-size" and "other-size" imports, respectively, on price for a given size class. Own-size imports are expected to have a larger impact on price of a given size shrimp than do other-size imports.

The parameter $TMCI_t$ was included to capture the effect that changing costs have on the demand for wholesale product. This term represents the individual components of the total intermediate food marketing cost index. Costs of marketing and processing are hypothesized to have an inverse relationship with the demand for and, thus, price of the "raw" product at the lower adjacent market level. Therefore, the coefficients α_4^W and b_4^4 are anticipated to be negative in sign.

Depending on whether the price determination process is characterized by upward causality, downward causality, or simultaneity, the β_i^W's and δ_i^W's may be associated with the retail and/or ex-vessel prices. As was the case with the retail expressions, the signs on current and lagged δ_1^W and β_i^W are anticipated to be positive.

The discussion regarding monthly and quarterly models for retail demand applies to the wholesale models as well. The monthly models use the data as reported. The quarterly models use an unweighted three-month average for the parameter $TMCI_t$ and for all prices found in the

corresponding M_i^W. The parameters OI_t^3, OI_t^2, $I31_t$, and $I21_t$ represent totals over three-month intervals of the raw data.

<u>Ex-vessel Price Models</u>

The monthly ex-vessel price model for 31-40 count raw-headless shrimp is given as

$$P_t^3 = \alpha_0^P + \sum_{i=1}^{NP} \alpha_i^P [M_3^P] + \alpha_1^P OL_t^3 + \alpha_2^P L31_t + \alpha_3^P TMCI_t + \xi_3'$$

and for 21-25 count raw-headless shrimp is given as

$$P_t^2 = b_0^P + \sum_{i=1}^{NP} \beta_i^P [M_2^P] + b_2^P OL_t^2 + b_2^P L21_t + b_3^P TMCI_t + \xi_2''$$

where

P_t^3 = ex-vessel price for the 31-40 size class (<u>Shellfish Market Review</u>, NMFS),

P_t^2 = ex-vessel price for the 21-25 size class (<u>Shellfish Market Review</u>, NMFS),

OL_t^3 = total domestic landings for all sizes of shrimp excluding the 31-40 size class landings in millions of pounds (<u>Shellfish Market Review</u>, NMFS),

OL_t^2 = total domestic landings of all sizes of shrimp excluding the 21-25 size class landings in millions of pounds (<u>Shellfish Market Review</u>, NMFS),

$L31_t$ = landings of shrimp in the 31-40 size class in the Gulf and South Atlantic in millions of pounds (NMFS unpublished files),

$L21_t$ = landings of shrimp in the 21-25 size class in the Gulf and South Atlantic in millions of pounds (NMFS unpublished files),

$TMCI_t$ = intermediate food marketing cost index, 1967=100 (Agricultural Outlook, USDA and unpublished USDA files),

NP = number of current and lagged exogenous and exogenous prices found in M_i^P for each size class model, where i refers to size class,

and α_i^P, δ_i^P, b_i^P, and β_i^P are the coefficients to be estimated. Each δ_i^P and β_i^P is associated with a current or lagged endogenous or exogenous price contained in M_3^P and M_2^P, respectively.

The ex-vessel price expression represents the demand by first handlers for raw product and corresponds to equation (33). The ex-vessel price data represents a dockside price (pack-out or box-weight price not specified). Prior to 1980, the ex-vessel price represents a weighted average for all species of shrimp landed in the Gulf and South Atlantic. From 1980 to 1981 the price data as reported represents a weighted average for species landed in the Western Gulf only. There appeared to be no appreciable change in the magnitude and trend of the prices when this structural change in the data occurred.

Ex-vessel price was specified as a function of the quantities offered to first handlers and costs incurred in the initial wholesale/processing stages. The quantity variable Q_D^F found in expression (33) has been separated into two component quantities - landings of all sizes excluding the size class of interest and landings of only the size class of interest. The quantity landed was broken down into two components, OL_t and $L31_t$ for the 31-40 size class and OL_t and $L21_t$ for

the 21-25 size class. This disaggregation was done to measure the relative impact of "own-size" and "other size" landings on ex-vessel price for a given size class. Own-size landings are expected to have a greater impact on the ex-vessel price of the corresponding size class. Though the quantity of shrimp brought to the unloading house is considered to depend primarily on environmental conditions, the price offered by the unloading house to the vessel operator for the shrimp is hypothesized to be inversely related to quantity landed. Thus, the coefficients α_1^P, α_2^P, b_1^P, b_2^P are expected to have a negative sign.

The parameter $TMCI_t$ was included to measure the effect that changing wholesale and processing costs have on the dockside price that emerges from the first handler/producer transaction. Most shrimp landed are sold to a dockside fish house. The product is then sold and trucked to wholesalers or processors for packaging, branding, etc. Cost data for first handlers of the shrimp are not available. Therefore, the aggregate cost index was included as a proxy for the costs which may influence the demand by first handlers for raw product. Given that this cost index more nearly approximate costs at the wholesale/processor market levels, ex-vessel price is hypothesized to have an inverse relationship with changes in $TMCI_t$. Thus, the coefficients b_3^P and $\alpha_3{}^P$ are hypothesized to be negative in sign.

The prices which are found in each M_1^P depend on whether the price determination process between ex-vessel and wholesale price is characterized by recursivity or simultaneity. The signs on current and lagged δ_1^P and β_1^P are hypothesized to be positive.

The ex-vessel price models described above represent the monthly and quarterly specifications. The monthly data are as described. The

quarterly data have been redefined such that $TMCI_t$ and the prices which may appear in each M_i^P represent simple three-month averages of the monthly data. The parameters OL_t^3, OL_t^2, $L31_t$, and $L21_t$ represent three-month totals of the monthly data.

Margin Models

Estimation of the monthly and quarterly price dependent demand models provides a set of structural coefficients for each model. These estimated coefficients can be utilized to derive a system of expressions describing the price spreads (margins) between adjacent market levels for each size class. Exact specification of these margin models is conditional on the lead/lag structures identified by the causality analysis. The interpretation of the derived estimates for prices in the margin models strictly depends on the nature of price determination and the identification of the causal market level(s). Non-price parameter estimates in the margin models will vary in sign depending on which prices are identified as exogenous or endogenous in the structural models. In addition, the derivation of the margin estimates is conditional on whether structural, reduced form, or final form estimates are utilized. A brief discussion of margins follows derived from structural and reduced or final form estimates.

Structural Margins

This discussion of margin models assumes symmetric price response, no price lags, and recursive price determination arbitrarily stated to be upward between wholesale and retail prices. Given these conditions, the margin between wholesale and retail price can be written simply as

$$M_t = \alpha + \beta_t^W W_t$$

and by definition

$$M_t = R_t - W_t$$

where M_t, R_r, and W_t, are margin, retail price, and wholesale price at time t, respectively. Since wholesale price is the causal price, retail price can be written in structural form as

$$R_t = a + bW_t$$

Then by substitution

$$M_t = a + bW_t - W_t$$

$$M_t = \alpha + \beta W_t$$

where $\alpha = a$ and $\beta = b-1$. The terms α and β are the absolute and percentage components of the margin, respectively (George and King, 1971). If the retail price is assumed to be the causal price, then wholesale price can be written in structural form as

$$W_t = a + bR_t$$

Then by substitution

$$M_t = R_t - (a + bR_t)$$

$$M_t = \alpha + \beta R_t$$

where $\alpha = -a$ and $\beta = 1 - b$. Thus, the interpretation of the absolute component (α) and the percentage component of price (β) depend on the direction of price determination between the adjacent market levels.

These margin expressions are in terms of price. The structural price models to be estimated also contain non-price parameters.

Depending on the direction of price determination as revealed in the causality analysis, the coefficient estimates associated with these non-price parameters may vary in sign but possess the same absolute value relative to the structural coefficient estimate. For a non-price coefficient b_i in either the retail or wholesale structural model, a recursive upward price causality relationship between adjacent retail and wholesale market levels produces a corresponding coefficient in the margin model with the same sign and absolute value as b_i found in the retail model. Alternatively, for a coefficient b_i in either the retail or wholesale structural model, a recursive downward price causality relationship between adjacent market levels produces a corresponding coefficient in the margin model with the same sign and absolute value as b_i found in the retail model. Alternatively, for a coefficient b_i in either the retail or wholesale structural model, a recursive downward price causality relationship between adjacent market levels produces a corresponding coefficient in the margin model with the opposite sign and same absolute value as b_i as found in the wholesale model. Given this method of derivation, the margins obtained from recursive structural estimates allow inferences to be made about the effects on the margin due to changes in exogenous variables from only one side of the margin. This is due to the margin being expressed in terms of only the causal price.

Reduced and Final Form Margins

Margin models can be derived from the reduced or final form coefficient estimates of the structural price models. If the structural models are recursive or simultaneous and do not contain lagged prices,

margin models are derived from the reduced form estimates. In the presence of lagged endogenous prices, final form estimates are utilized to obtain the margin models. In any case, the reduced or final form margin expressions are not functions of current endogenous price parameters. Only exogenous non-price parameters will appear in the reduced or final form margin expressions (lagged prices may appear in the reduced forms). Thus, the procedure for obtaining structural margin models is not applicable for the reduced and final form margin models.

Given that the retail/wholesale price spread is defined as $M_t^{rw} = R_t - W_t$ and the wholesale/ex-vessel price spread is defined as $M_t^{wp} = W_t - P_t$, a structural margin allows for change in exogenous variables through a single price—the causal price. Alternatively, the reduced or final form margin model allows for change in exogenous variables through both prices. The coefficients in the reduced or final form margins models are simply the difference between the respective parameter estimates in the reduced or final forms for retail, wholesale, or ex-vessel price, which are expressed in terms of the same set of exogenous variables. Therefore, the sign and absolute value of the coefficient estimates in the reduced or final form margin model depend on the relative magnitude of the respective reduced or final form coefficient estimates.

Thus, there are two forms of margin expressions - margins obtained from structural estimates and margins obtained from reduced or final form estimates. The structural margins allow inferences to be made regarding change in non-price variables from only one side of the margin, whereas, the reduced and final form margins examine changes from both sides of the margin.

CHAPTER V
EMPIRICAL RESULTS—CAUSALITY ANALYSIS

The causal relationships between prices at three market levels were investigated using Haugh-Pierce, Granger, and Sims techniques for two size classes of shrimp. The Haugh-Pierce test was employed to test hypotheses regarding unidirectional and instantaneous causality, whereas the Granger and Sims tests were utilized to test hypotheses regarding strictly unidirectional causality. Monthly and quarterly time series data over the years 1968-1981 and 1972-1981, respectively, were examined. The findings are presented by estimation procedure utilized for the 31-40 and 21-25 size classes on a monthly and quarterly basis. The results are summarized to highlight contrasts and similarities between the two size classes.

Monthly Price Data

Haugh-Pierce Test

The Haugh-Pierce procedure provides a means by which the data can suggest the lead/lag relationship that exists between the two series of data. This is accomplished by analyzing the cross correlations between current and lagged observations in white noise residual series to detect instantaneous and unidirectional causality under the null hypothesis that the series are independent. Further, the Haugh-Pierce procedure provides the necessary information to construct dynamic shock models and impulse response functions that allow explicit specification of a

distributed lag model that relates the two price series once the causal relationship has been identified. This specification ability is not provided by the Granger or Sims approach and is necessary to specify a complete econometric model of price dependent demands.

The Haugh-Pierce procedure requires that each price series for both size classes be reduced to a white noise process. The estimated time series ARIMA filter models that were necessary to transform the price series for the 31-40 size class into approximately white noise processes were found to be

$$\underset{}{(1-B)(1\ \underset{(.072)}{-.390B} + \underset{(.073)}{.135B^3})E_t = e_t} \quad , \text{ B-P } \chi^2_{18}=17.44 \text{ and } \sigma_e=.149$$

$$(1-B)(1 - \underset{(.078)}{.466B} + \underset{(.079)}{.093B^2})W_t = w_t \quad , \text{ B-P } \chi^2_{18}=20.88 \text{ and } \sigma_w=.129$$

$$(1-B)(1 - \underset{(.075)}{.352B} - \underset{(.069)}{.276B^8} + \underset{(.079)}{.235B^9})R_t = r_t \quad , \text{ B-P } \chi^2_{18}=20.69 \text{ and } \sigma_r=.199$$

where E_t, W_t, and R_t are ex-vessel, wholesale, and retail price, respectively, e_t, w_t, and r_t are the corresponding white noise residuals, B-P refers to the Box-Pierce chi-square statistic, σ is the standard deviation associated with each white noise residual series, and the values in parentheses are standard errors of the estimates. The ARIMA models that were necessary to transform the price series for the 21-25 size class into approximately white noise processes were found to be

$$(1-B)(1 - \underset{(.076)}{.239B} + \underset{(.080)}{.098B^3} + \underset{(.089)}{.115B^5})E_t = e_t \quad , \text{ B-P } \chi^2_{17}=14.27 \text{ and } \sigma_e=.205$$

$$(1-B)(1 - \underset{(.076)}{.281B} + \underset{(.077)}{.113B^3})W_t = w_t \quad , \text{ B-P } \chi^2_{18}=14.40 \text{ and } \sigma_w=.217$$

$$(1-B)(1 - \underset{(.077)}{.1944B})R_t = r_t \quad , \text{ B-P } \chi^2_{17}=9.98 \text{ and } \sigma_r=.215$$

where the terms are defined as for the models pertaining to the 31-40 size class. The calculated Box-Pierce statistics for both size classes support the hypotheses that the residual series are white noise at the .05 level. The above filter models are integrated (homogeneous degree one) autoregressive with no moving average component. The Sims "universal filter" given as $(1-.75B)^2$ (Bishop, 1979) was applied to each series but did not transform the series into white noise. A lag of twelve periods was used on all tests at the monthly level. Empirical research on price movement in the shrimp market has not shown statistically significant periodicity other than seasonal fluctuations (Thompson and Roberts, 1982). Therefore, a full year was assumed sufficient to capture all pertinent price responses. The number of observations used for each causality test differed slightly due to the lag structure of the ARIMA models used to filter the corresponding price series.

The 31-40 size class

The Haugh-Pierce tests for causality between the residual series of ex-vessel and wholesale prices indicated that unidirectional causality exists such that ex-vessel price causes (leads) wholesale price (Test I in Table 1). The Haugh-Pierce statistic relevant to the null hypothesis that ex-vessel does not cause wholesale price was larger than the tabulated critical chi-square value at 12 degrees of freedom and, thus, the null hypothesis is rejected at the .05 percent level. However, the null hypothesis that wholesale does not cause ex-vessel price was not rejected. Thus, unidirectional causality exists such that ex-vessel causes wholesale price. A lag of one period was significant. The current cross correlations were significant for both lead/lag alternatives in Test I, indicating instantaneous causality exists such that current ex-vessel causes current wholesale prices, and vice versa.

Table 1. Haugh-Pierce (H-P) Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 31-40 Size Class Using ARIMA Filtered Data.

Series 1 = Prewhitened Ex-vessel Prices
Series 2 = Prewhitened Wholesale Prices
Series 3 = Prewhitened Retail Prices

	TEST I (N = 162)[a]		TEST II (N = 158)[a]	
Lag (k) in Causal Series j	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{2,1}(k)$	(b) $\hat{r}_{1,2}(k)$	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{3,2}(k)$	(b) $\hat{r}_{2,3}(k)$
0	.752*	.753*	.186*	.186*
1	.291*	-.051	.360*	.087
2	-.080	-.100	.092	-.005
3	.068	.058	.011	.011
4	-.026	.054	.175*	.045
5	-.036	-.015	-.028	-.051
6	-.076	-.003	.074	.155
7	.063	.043	-.072	-.026
8	.005	.050	.001	-.092
9	.045	.079	.091	-.043
10	.051	-.075	-.038	.005
11	-.115	-.048	-.015	-.089
12	-.057	-.027	.049	.050

TEST I:

(a) Null Hypothesis: ex-vessel does not cause wholesale price,

H-P χ^2_{12} = 21.16**

(b) Null Hypothesis: wholesale does not cause ex-vessel price,

H-P χ^2_{12} = 6.40***

TEST II:

(a) Null Hypothesis: wholesale does not cause retail price,

H-P χ^2_{12} = 30.18**

(b) Null Hypothesis: retail does not cause wholesale price,

H-P χ^2_{12} = 9.32***

[a]N is the effective number of observations for cross correlation.

*Greater than two standard errors (s), where $s = N^{-1/2}$.

**Reject null hypothesis at the .05 level.

***Fail to reject null hypothesis at the .10 level.

The tests for causality between the price series at wholesale and retail market levels indicated that wholesale price leads retail (Test II in Table 1). Significant lags exist at one, four, and nine periods. The insignificant current cross correlations indicated that no instantaneous causality exists between retail and wholesale prices.

The 21-25 size class

The Haugh-Pierce test was applied to ex-vessel and wholesale prices for 21-25 count price data (Test I in Table 2). The null hypothesis that wholesale does not cause ex-vessel price was not rejected. The null hypothesis that ex-vessel does not cause wholesale price was also not rejected at the .05 level. Thus, unidirectional causality was found not to exist between ex-vessel and wholesale prices when lags of up to 12 periods were examined. A lag of one period was significant. However, the significant current cross correlation relative to both tests suggested instantaneous causality exists such that ex-vessel and wholesale price are instantaneously related only.

The test for causal direction between wholesale and retail price series indicated that unidirectional causality exists only such that wholesale causes retail price at the .05 level (Test II in Table 2). Lags of one and two periods were significant. The insignificant current cross correlation suggested that no instantaneous causality exists between wholesale and retail price series.

Impulse response functions for both size classes

The residual cross correlations generated by the Haugh-Pierce test provide necessary information to be used in the specification of the exact nature of the lead/lag relationships suggested by the causality

Table 2. Haugh-Pierce (H-P) Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 21-25 Size Class Using ARIMA Filtered Data.

Series 1 = Prewhitened Ex-vessel Prices
Series 2 = Prewhitened Wholesale Prices
Series 3 = Prewhitened Retail Prices

	TEST I (N = 162)[a]		TEST II (N = 166)[a]	
Lag (k) in Causal Series j	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{2,1}(k)$	(b) $\hat{r}_{1,2}(k)$	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{3,2}(k)$	(b) $\hat{r}_{2,3}(k)$
0	.836*	.836*	.100	.100
1	.167*	-.037	.227*	.130
2	.005	.041	.389*	.059
3	-.010	-.063	.129	.061
4	.033	.020	.017	.014
5	-.026	.012	.022	-.080
6	-.027	-.044	.106	-.027
7	-.065	.087	.090	-.073
8	.017	-.064	-.027	-.078
9	-.038	-.012	.004	-.143
10	.100	.101	.040	-.081
11	-.069	-.141	.114	-.074
12	-.182*	-.128	.081	-.064

TEST I:

(a) Null Hypothesis: ex-vessel does not cause wholesale price,
H-P χ^2_{12} = 13.61***

(b) Null Hypothesis: wholesale does not cause ex-vessel price,
H-P χ^2_{12} = 6.40***

TEST II:

(a) Null Hypothesis: wholesale does not cause retail price,
H-P χ^2_{12} = 44.02**

(b) Null Hypothesis: retail does not cause wholesale price,
H-P χ^2_{12} = 13.10***

[a]N is the effective number of observations for cross correlation.

*Greater than two standard errors (s), where $s = N^{-1/2}$.

**Reject null hypothesis at the .05 level.

***Fail to reject null hypothesis at the .10 level.

test. The cross correlations are utilized in constructing the impulse response functions or distributed lag expressions which are the necessary next step in operationalizing the causality results. These distributed lag expressions are utilized in the final specification of the econometric model of prices. For the sake of simplicity and expediency, the following discussion will center on only two price series for the 31-40 size class.

The Haugh-Pierce causality tests produced a set of residual cross correlations between ex-vessel and wholesale 31-40 price series (Test I in Table 1). The significance patterns in the estimated residual cross correlations and the indicated causal direction suggested a dynamic shock model written in backshift notation as

$$w_t = (\lambda_0 - \lambda_1 B)e_t + (1 - \phi_1 B)a_t$$

where λ_0 and λ_1 are impulse response weights at zero and one lags, e_t and w_t are the white noise residuals for the prewhitened ex-vessel and wholesale price series, respectively, and a_t is some white noise process written in first-order polynomial form in terms of ϕ. The parameter estimates of λ_0 and λ_1 are given as

$$\hat{\lambda}_0 = \left(\frac{\sigma_w}{\sigma_e}\right)\hat{r}_{2,1}(0) = \frac{.129}{.149}(.752) = .651$$

$$\hat{\lambda}_1 = \left(\frac{\sigma_w}{\sigma_e}\right)\hat{r}_{2,1}(1) = \frac{.129}{.149}(.291) = .252$$

The dynamic shock model can then be rewritten as

$$w_t = (.651 - .252B)e_t + (1 - \phi_1 B)a_t$$

The ARIMA filter models for ex-vessel and wholesale price series are

$$(1-B)(1 - .390B + .135B^3)E_t = e_t$$

$$(1-B)(1 - .466B + .093B^2)W_t = w_t$$

where E_t and W_t are ex-vessel and wholesale price, respectively. Substituting the above ARIMA expressions for e_t and w_t into the dynamic shock model yields the expression

$$(1-B)(1 - .466B + .093B^2)W_t = (.651 - .252B)(1-B)(1 - .390B + .135B^3)E_t + (1 - \phi B)a_t$$

which is the impulse response function. By carrying out the indicated multiplication and division, the above expression reduces to

$$W_t = (.651 - .203B - .058B^2 + .078B^3 + .006B^4 - .006B^5 - .015B^6 - .013B^7 - .002B^8 - .001B^9 - .001B^{10})E_t + \theta(B)a_t$$

where $\theta(B)$ is some polynomial on the error term a_t. By dropping all terms that are small relative to the leading parameters (less than .1), W_t can be expressed in a more parsimonious form as

$$W_t = (.651 - .203B)E_t + \theta(B)a_t$$

Thus, the Haugh-Pierce causality results and the impulse response function derivation suggested that current wholesale price be expressed as some function of current ex-vessel price and ex-vessel price lagged one period. Therefore, the final specification of the price dependent demand expression at the wholesale level for 31-40 size class raw-headless shrimp contains current ex-vessel price of 31-40 size product and ex-vessel price lagged one period. The derivation of the monthly impulse response functions for the 31-40 size class retail/wholesale and 21-25 size class retail/wholesale market level interfaces are presented

in Appendix A. The final parsimonious forms, however, are given for the 31-40 size class as

$$\text{(i)} \quad R_t = (.246 - .504B - .204B^4)W_t + \theta_1(B)v_t$$

and for the 21-25 size class as

$$\text{(ii)} \quad R_t = (.099 - .235B - .371B^2)W_t + \theta_2(B)u_t$$

where R_t and W_t are retail and wholesale price, respectively, $\theta_1(B)$ and $\theta_2(B)$ are polynomials on the error terms v_t and u_t, respectively.

The Granger Test

The Granger procedure allows the testing for the presence of unidirectional causality utilizing stationary time series data. The analysis provides insight into the lag relationships linking prices between adjacent market levels. The following analysis utilized first differenced and ARIMA filtered price series representing each size class at the ex-vessel/wholesale and wholesale/retail market level interfaces. Lags of twelve months were also used for the Granger tests.

The 31-40 size class

The Granger test for causality was applied to the prices for the 31-40 size class. The prices were first differenced ($p_t - p_{t-1}$) to transform them to an approximate stationary series. Unidirectional causality was found to exist such that ex-vessel causes wholesale price (Table 3). In addition, the null hypothesis of no unidirectional causality from wholesale to ex-vessel price was not rejected. These findings indicated the ex-vessel price was causing wholesale price. Note that the Box-Pierce statistic for each first differenced series was greater than the critical χ^2 value, indicating that the first differenced data

Table 3: Granger Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 31-40 Size Class Using First Differenced Data.[a]

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

° Unidirectional Test: $F_{12,121} = 1.52$**

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

° Unidirectional Test: $F_{12,121} = 3.73$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

° Unidirectional Test: $F_{12,130} = 1.22$**

D. NULL HYPOTHESIS: wholesale does not cause retail price

° Unidirectional Test: $F_{12,130} = 4.12$*

[a]First differenced data for ex-vessel, wholesale, and retail prices have residual Box-Pierce statistics of 53.29, 69.75, and 50.43, respectively. These should be compared to a tabulated critical chi-square value at 20 degrees of freedom of 31.14 at the .05 level.

*Reject null hypothesis at the .01 level.

**Fail to reject null hypothesis at the .10 level.

is not white noise at the .05 percent level. Thus, due to the presence of serial dependence, the possibility of spurious results exists.

The Granger test was repeated for data transformed by an appropriate ARIMA filter (Appendix C). The ARIMA filter models necessary to transform the two series into approximately white noise residuals were the same as those used in the Haugh-Pierce tests. The resulting Box-Pierce statistics indicated that the residuals for filtered ex-vessel and wholesale data, e_t and w_t, respectively, are white noise at the .05 level. Unidirectional causality was again found to exist only such that ex-vessel causes wholesale price. Thus for the ex-vessel/wholesale test the results using first differenced data are identical to the results using data filtered by an ARIMA model. However, the latter approach reduces the chances of spurious regression.

The same tests were applied to the wholesale and retail price series (Table 3). First differencing did not transform the price series into white noise. However, the use of the ARIMA filters utilized in the Haugh-Pierce test did transform the price series into white noise processes. The results were invariant relative to first differencing (Table 3) or filtering by an ARIMA model (Appendix B). In both cases the tests supported the null hypotheses that retail does not cause wholesale price in a unidirectional sense and rejects the null hypotheses that wholesale does not cause retail price. Thus, it appears there was significant unidirectional causality between wholesale and retail market levels such that wholesale causes retail price. In this case, retail prices would be most appropriately specified as some function of lagged wholesale price.

<u>The 21-25 size class</u>

The results of the Granger test for causality between ex-vessel and wholesale monthly prices using first differenced data for 21-25 size class are presented in Table 4. Two null hypotheses tested are that wholesale price does not cause ex-vessel price and ex-vessel price does not cause wholesale price. Each null hypothesis was tested for the absence of unidirectional causality. The test finds no evidence of unidirectional causality from wholesale to ex-vessel price. Thus, expressing ex-vessel price as some function of lagged wholesale price was not supported. Note, however, that first differencing did not transform the wholesale series into a white noise process. The second null hypothesis, however, was rejected at the .01 level for unidirectional causality such that ex-vessel causes wholesale price. Thus, the causal relationship between the two series was such that wholesale price should be specified as some function of lagged ex-vessel price.

Since first differencing did not transform the wholesale price series into a white noise process, the test was repeated using ex-vessel and wholesale price data filtered by an appropriate ARIMA model (Appendix C). The ARIMA models utilized to transform the ex-vessel and wholesale price series into white noise were the same as those discussed for the Haugh-Pierce test. Box-Pierce statistics indicate that the residuals for ex-vessel and wholesale data, e_t and w_t, respectively, are white noise at the .05 level. The results using the filtered data, however, were invariant to the results using first differenced data.

The Granger test was also used to analyze the causal relationship between wholesale and retail prices. The test was applied to first differenced data (Table 3) and data filtered by appropriate ARIMA models

Table 4: Granger Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 21-25 Size Class Using First Differenced Data.[a]

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

- Unidirectional Test: $F_{12,130} = 1.04$**

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

- Unidirectional Test: $F_{12,130} = 2.86$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

- Unidirectional Test: $F_{12,130} = 1.30$**

D. NULL HYPOTHESIS: wholesale does not cause retail price

- Unidirectional Test: $F_{12,130} = 3.38$**

[a]First differenced data for ex-vessel, wholesale, and retail prices have residual Box-Pierce statistics of 30.47, 32.64, and 21.09, respectively. These should be compared to a tabulated critical chi-square value at 20 degrees of freedom of 31.14 at the .05 level.

*Reject null hypothesis at the .01 level.

**Fail to reject null hypothesis at the .10 level.

(Appendix C). The ARIMA filter that was utilized to transform the retail price series into a white noise was the same as that used in the Haugh-Pierce test. The Box-Pierce statistic for both first-differenced and ARIMA filtered retail data indicates that the residuals are white noise. The tests for unidirectional causality for both the first differenced and filtered data indicated that the null hypothesis suggesting retail does not cause wholesale price was not rejected. However, the null hypothesis that wholesale does not cause retail price was rejected at the .01 level. These findings suggest that retail price be expressed as some function of lagged wholesale price. As with the ex-vessel and wholesale market levels, the results were invariant with reapect to the filtering procedure.

Sims Test

The Sims procedure offers a second alternative test for unidirectional causality between adjacent market levels. Additionally, the Sims procedure requires the use of data that has been transformed to a white noise process. The same ARIMA filter models that were utilized for the Haugh-Pierce procedure are utilized for the Sims test. Recall that the filters did an adequate job of transforming all of the original series into white noise processes based on the Box-Pierce statistics. The Sims test also utilized twelve lags.

The 31-40 size class

The Sims causality test indicated that the unidirectional causality exists such that ex-vessel causes wholesale price and wholesale causes retail price (Table 5). The null hypotheses of no causality in the opposite direction were not rejected at the .10 level. This finding

Table 5: Sims Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 31-40 and 21-25 Size Classes Using ARIMA Filtered Data.

31-40 Size Class	21-25 Size Class
A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price	A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price
° Unidirectional Test: $F_{11,109} = 0.79$**	° Unidirectional Test: $F_{11,113} = 2.47$*
B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price	B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price
° Unidirectional Test: $F_{11,109} = 3.03$*	° Unidirectional Test: $F_{11,113} = 4.05$*
C. NULL HYPOTHESIS: retail does not cause wholesale price	C. NULL HYPOTHESIS: retail does not cause wholesale price
° Unidirectional Test: $F_{11,109} = 0.86$**	° Unidirectional Test: $F_{11,113} = 0.86$**
D. NULL HYPOTHESIS: wholesale does not cause retail price	D. NULL HYPOTHESIS: wholesale does not cause retail price
° Unidirectional Test: $F_{11,109} = 3.78$*	° Unidirectional Test: $F_{11,113} = 4.73$*

*Reject null hypothesis at the .01 level.

**Fail to reject null hypothesis at the .10 level.

suggested that the causal relationship between ex-vessel and wholesale prices is recursive upward. Thus, wholesale prices should be expressed as some lagged function of ex-vessel prices. Similarly, the causal relationship between wholesale and retail prices was found to be recursive upward. Retail prices would be appropriately specified as some function of lagged wholesale price.

The 21-25 size class

The causal relationship between ex-vessel, wholesale, and retail price series using the Sims test indicated the presence of feedback between ex-vessel and wholesale prices (Table 5). The null hypotheses stating that ex-vessel does not cause wholesale price and wholesale does not cause ex-vessel price were both rejected at the .01 level. Thus, feedback is present between ex-vessel and wholesale prices. The null hypothesis of no unidirectional causality from retail to wholesale price was not rejected, whereas the null hypothesis of no unidirectional causality from wholesale to retail price was rejected at the .01 level. Thus, the causal relationship between wholesale and retail price is unidirectional such that wholesale causes retail price.

Quarterly Price Data

The Haugh-Pierce, Granger, and Sims tests for causality were also applied to quarterly data. This analysis was performed to gain insights into how the process of price determination between the three market levels evolves as the observational time period is increased from a one-month to a three-month interval.

Haugh-Pierce Test

The Haugh-Pierce test for instantaneous and unidirectional causality utilized quarterly data filtered by appropriate ARIMA models. The ARIMA filter models necessary to transform the original quarterly price data for the 31-40 size class into approximate white noise processes are given in terms of the backshift operator B as

$$\underset{}{(1-B)(1-\underset{(.147)}{.161}B^3+\underset{(.155)}{.409}B^6)E_t = e_t} \quad , \text{ B-P } \chi^2_{18}=19.08 \text{ and } \sigma_e=.305$$

$$(1-B)(1-\underset{(.143)}{.165}B+\underset{(.150)}{.344}B^6)W_t = w_t \quad , \text{ B-P } \chi^2_{18}=13.01 \text{ and } \sigma_w=.279$$

$$(1-B)(1-\underset{(.125)}{.417}B)R_t = r_t \quad , \text{ B-P } \chi^2_{19}=13.00 \text{ and } \sigma_r=.341$$

where E_t and W_t, and R_t are ex-vessel, wholesale, and retail prices, respectively, e_t, w_t, and r_t are the corresponding white noise residuals, B-P refers to the Box-Pierce chi-square statistic, σ is the standard deviation associated with each white noise residual series, and the values in parentheses are standard errors of the estimates. The ARIMA filter models necessary to transform the original quarterly price data for the 21-25 size class into approximate white noise processes are given in terms of the backshift operator as

$$(1-B)(1-\underset{(.151)}{.169}B^2+\underset{(.161)}{.203}B^4+\underset{(.169)}{.425}B^6)E_t = e_t \quad , \text{ B-P } \chi^2_{17}=12.72 \text{ and } \sigma_e=.349$$

$$(1-B)(1+\underset{(.161)}{.259}B^4+\underset{(.166)}{.334}B^6)W_t = w_t \quad , \text{ B-P } \chi^2_{18}=8.34 \text{ and } \sigma_w=.385$$

$$(1-B)(1-\underset{(.127)}{.460}B+\underset{(.130)}{.154}B^5)R_t = r_t \quad , \text{ B-P } \chi^2_{18}=8.24 \text{ and } \sigma_r=.322$$

where the terms are defined as for the models pertaining to the 31-40 size class. The calculated Box-Pierce statistics for both size classes supported the hypothesis that the residual series are white noise processes at the .05 level. The quarterly filter models are integrated (homogeneous degree one) autoregressive with no moving average component. A lag of six quarters (1.5 years) was considered sufficient to capture all pertinent price response. Price responses between market levels lagged beyond 1.5 years were considered unlikely. This results from the need to market fresh frozen shrimp quickly, due to a relatively short shelf life.

The 31-40 size class

The null hypotheses of no unidirectional causality were not rejected at a minimum .10 level in all cases (Table 6). Thus, unidirectional causality was not present. The virtual absence of any significant lagged residual cross correlation terms ($k>0$) further illustrates the lack of a unidirectional causal relationship between the prices. However, the highly significant zero lag ($k=0$) cross correlation term indicated the presence of instantaneous causality (in the Pierce definition) such that ex-vessel, wholesale, and retail prices are instantaneously related only.

The 21-25 size class

The findings for the 21-25 size class prices were the same as for the 31-40 size class prices (Table 7). Failure to reject the null hypotheses of no unidirectional causality at the .10 level for both the ex-vessel/wholesale and wholesale/retail relationships indicated that unidirectional causality in either direction does not exist. The

Table 6. Haugh-Pierce (H-P) Causality Tests on Quarterly Ex-vessel, Wholesale, and Retail Prices for the 31-40 Size Class Using ARIMA Filtered Data.

Series 1 = Prewhitened Ex-vessel Prices
Series 2 = Prewhitened Wholesale Prices
Series 3 = Prewhitened Retail Prices

	TEST I (N = 49)[a]		TEST II (N = 49)[a]	
Lag (k) in Causal Series j	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{2,1}(k)$	(b) $\hat{r}_{1,2}(k)$	Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{3,2}(k)$	(b) $\hat{r}_{2,3}(k)$
0	.912*	.912*	.618*	.618*
1	.059	-.058	.248	-.033
2	-.075	-.030	-.097	.050
3	.022	-.082	.119	-.107
4	-.158	-.163	-.052	-.123
5	-.211	-.148	-.319*	-.207
6	-.001	.049	-.128	.029

TEST I:

(a) Null Hypothesis: ex-vessel does not cause wholesale price,
H-P $\chi^2_6 = 3.87$**

(b) Null Hypothesis: wholesale does not cause ex-vessel price,
H-P $\chi^2_6 = 3.40$**

TEST II:

(a) Null Hypothesis: wholesale does not cause retail price,
H-P $\chi^2_6 = 10.09$**

(b) Null Hypothesis: retail does not cause wholesale price,
H-P $\chi^2_6 = 3.63$**

[a]N is the effective number of observations for cross correlation.

*Greater than two standard errors (s), where $s = N^{-1/2}$.

**Fail to reject null hypothesis at .10 level.

Table 7. Haugh-Pierce (H-P) Causality Tests on Quarterly Ex-vessel, Wholesale, and Retail Prices for the 21-25 Size Class Using ARIMA Filtered Data.

Series 1 = Prewhitened Ex-vessel Prices
Series 2 = Prewhitened Wholesale Prices
Series 3 = Prewhitened Retail Prices

Lag (k) in Causal Series j	TEST I $(N = 49)^a$ Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{2,1}(k)$	TEST I $(N = 49)^a$ Cross Correlations $\{\hat{r}_{ij}(k)\}$ (b) $\hat{r}_{1,2}(k)$	TEST II $(N = 49)^a$ Cross Correlations $\{\hat{r}_{ij}(k)\}$ (a) $\hat{r}_{3,2}(k)$	TEST II $(N = 49)^a$ Cross Correlations $\{\hat{r}_{ij}(k)\}$ (b) $\hat{r}_{2,3}(k)$
0	.934*	.934*	.469*	.469*
1	.152	-.044	.127	.208
2	-.186	-.032	-.066	-.049
3	-.084	-.049	-.152	-.133
4	-.060	-.104	.055	.011
5	-.066	-.166	-.096	-.238
6	-.124	-.003	-.114	.080

TEST I:

(a) Null Hypothesis: ex-vessel does not cause wholesale price,
H-P $\chi^2_6 = 4.31$**

(b) Null Hypothesis: wholesale does not cause ex-vessel price,
H-P $\chi^2_6 = 2.16$**

TEST II:

(a) Null Hypothesis: wholesale does not cause retail price,
H-P $\chi^2_6 = 3.33$**

(b) Null Hypothesis: retail does not cause wholesale price,
H-P $\chi^2_6 = 4.07$**

[a]N is the effective number of observations for cross correlation.

*Greater than two standard errors (s), where $s = N^{-1/2}$.

**Fail to reject null hypothesis at .10 level.

absence of any significant residual cross correlations further illustrates this finding. As with the analysis with the 31-40 size class prices, the zero lag residual cross correlations are significant, indicating the presence of instantaneous causality in the Pierce definition. Notice that zero lag cross correlations for the 21-25 size class are roughly the same size at the ex-vessel/wholesale relationship but smaller at the retail/wholesale relationship than for the 31-40 size class data, suggesting in general a stronger instantaneous relationship for the prices of the smaller shrimp product.

Impulse response functions for both size classes

The residual cross-correlations generated by the Haugh-Pierce test were used to construct a set of impulse response functions which capture the lead/lag properties that exist for the ex-vessel/wholesale and wholesale/retail quarterly price relationships for each size class. The definition and derivation of these expressions have been discussed for the monthly price analysis and will not be repeated. The stepwise process of deriving these expressions for the quarterly data is presented in Appendix A. Thus, only the resulting final parsimonious expressions, written in terms of the backshift operator B, will be discussed in this section.

The Haugh-Pierce analysis indicated that the ex-vessel/wholesale and wholesale/retail price relationships were characterized by instantaneous causality running both directions. In addition, no unidirectional causality was found. Therefore, these price series are related in a fully simultaneous, rather than recursive, nature. To accommodate this characteristic, two impulse response functions were specified for

the ex-vessel/wholesale and wholesale/retail relationship for each size class.

The parsimonious form of the two impulse functions corresponding to the ex-vessel/wholesale relationship for the 31-40 size class are given as

$$W_t = (.834)E_t + \phi_1(B)a_t^1$$

$$E_t = (.998 - .165B)W_t + \phi_2(B)a_t^2$$

with the impulse response functions representing the wholesale/retail price relationship given as

$$W_t = (.505 - .128B)R_t + \phi_3(B)a_t^3$$

$$R_t = (.757 - .113B)W_t + \phi_4(B)a_t^4$$

where B is the backshift operator, R_t is retail price, W_t is wholesale price, E_t is ex-vessel price, and ϕ_i is some polynomial expression of the white noise error term a_t^i.

The impulse response functions for the same two price relationships as above, except for the 21-25 size class, and written in parsimonious form are shown as

$$W_t = (1.03 - .141B + .406B^2)E_t + \phi_1(B)a_t^1$$

$$E_t = (.847 - .143B^2)W_t + \phi_2(B)a_t^2$$

and

$$W_t = (.560 - .506B + .114B^2)R_t + \phi_3(B)a_t^3$$

$$R_t = (.393 + .181B)W_t + \phi_4(B)a_t^4$$

where the variables are defined as for the 31-40 size class expressions.

The exact lead/lag structure of the interdependent price relationships are unveiled in the impulse response functions. Note that the lag

structure is very short for the 31-40 size class price series, requiring a lag of at most only one period. However, the impulse response functions for the 21-25 size class prices require lags of up to two quarters. Price shocks appear to take longer to work through the system for the larger sized shrimp.

The impulse response functions are incorporated into a quarterly model of price at the ex-vessel, wholesale, and retail levels of the market. These impulse response expressions provide a means by which the lead/lag properties of prices between adjacent market levels may be embodied in a more complete econometric model.

Granger Test

The Granger test was applied to ex-vessel, wholesale, and retail prices for both size classes. The test was applied to price series transformed into approximate white noise processes by first differencing. A total of six lags were specified for the Granger tests.

The 31-40 size class

The Granger causality test applied to first differenced data indicated that the causal relationships between ex-vessel and wholesale and retail prices is not unidirectional (Table 8). All null hypotheses regarding the absence of strictly unidirectional causality were not rejected, thus no unidirectional causality in either direction is indicated. Note that first differencing the original series transformed the series into white noise, as indicated by the given Box-Pierce statistics at the .05 level. The same test was applied to first differenced wholesale and retail price series (Table 8). The null hypotheses regarding the absence of strictly unidirectional causality were not rejected at

Table 8: Granger Causality Tests on Quarterly Ex-vessel, Wholesale, and Retail Prices for the 31-40 Size Class Using First Differenced Data.[a]

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

° Unidirectional Test: $F_{6,20} = 0.69$*

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

° Unidirectional Test: $F_{6,20} = 1.34$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

° Unidirectional Test: $F_{6,20} = 0.34$*

D. NULL HYPOTHESIS: wholesale does not cause retail price

° Unidirectional Test: $F_{6,20} = 1.05$*

[a]First differenced ex-vessel, wholesale, and retail price data for the 31-40 size class have Box-Pierce statistics of 24.13, 21.14, and 29.64, respectively. These should be compared against a tabulated critical chi-square value at 20 degrees of freedom of 31.14 at the .05 level.

*Fail to reject null hypothesis at the .10 level.

the .10 level. The derived Box-Pierce statistics indicated that the first differenced series were approximately white noise. Thus, the absence of unidirectional causality characterized the first differenced quarterly 31-40 size class data.

The 21-25 size class

The Granger test on first differenced ex-vessel and wholesale prices indicated that both null hypotheses regarding the absence of unidirectional causality were not rejected (Table 9). The first differencing of the quarterly ex-vessel and wholesale price series did an adequate job of transforming the series into white noise processes, as indicated by the Box-Pierce statistics. Thus, unidirectional causality between ex-vessel and wholesale prices for the 21-25 count class was not found.

Testing the causal relationship between retail and wholesale prices using first differenced data indicated that no causal relationship exists (Table 9). Both hypotheses of no unidirectional causality were not rejected at both the .05 level. However, the Box-Pierce statistic for the first differenced retail price data indicated that the hypothesis that the residuals are white noise was not supported at the .05 level. Thus, as a check for robustness, the Granger test was also performed on the wholesale/retail relationship using ARIMA filtered data (Appendix B). The approximate ARIMA filter necessary to transform the original retail price series into white noise was the same as that used in the Haugh-Pierce test. The resulting Box-Pierce statistic shows that the residuals are approximately white noise when compared to a tabulated χ^2_{18} value of 28.9 at the .05 level. Both hypotheses regarding the

Table 9: Granger Causality Tests on Quarterly Ex-vessel, Wholesale, and Retail Prices for the 21-25 Size Class Using First Differenced Data.[a]

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

- Unidirectional Test: $F_{6,20} = 0.62$*

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

- Unidirectional Test: $F_{6,20} = 1.05$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

- Unidirectional Test: $F_{6,20} = 1.23$*

D. NULL HYPOTHESIS: wholesale does not cause retail price

- Unidirectional Test: $F_{6,20} = 0.74$*

[a]First differenced ex-vessel, wholesale, and retail price data for the 21-25 size class have Box-Pierce statistics of 21.04, 15.88, and 33.90, respectively. These should be compared against a tabulated critical chi-square value at 20 degrees of freedom of 31.14 at the .05 level.

*Fail to reject null hypothesis at the .10 level.

absence of unidirectional causality were not rejected at the .10 level. Thus, the findings were identical when either first differenced or ARIMA filtered data were utilized.

Sims Test

The Sims test for causality was applied to ex-vessel/wholesale and retail/wholesale price relationships using data prewhitened by ARIMA filters. The same filters as those used in the quarterly Haugh-Pierce test were used for the Sims test. A total of six lags were used for the Sims test.

The 31-40 size class

The ex-vessel/wholesale and wholesale/retail price relationships were examined for the absence of unidirectional causality (Table 10). Four null hypotheses of no causality were tested and all were not rejected at the .10 level. Thus, no unidirectional causal patterns were detected using the Sims test on prewhitened data.

The 21-25 size class

The ex-vessel/wholesale and wholesale/retail price relationships were examined for the absence of unidirectional causality (Table 10). As with the prewhitened prices representing the smaller size class of shrimp, unidirectional causality was found to be absent at the .10 level. Thus, all four null hypotheses of no causality could not be rejected.

Table 10: Sims Causality Tests on Quarterly Ex-vessel, Wholesale, and Retail Prices for the 31-40 and 21-25 Size Classes Using ARIMA Filtered Data.

31-40 Size Class	21-25 Size Class
A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price	A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price
° Unidirectional Test: $F_{5,8} = 0.30$*	° Unidirectional Test: $F_{8,8} = 0.33$*
B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price	B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price
° Unidirectional Test: $F_{5,8} = 0.50$*	° Unidirectional Test: $F_{8,8} = 0.26$*
C. NULL HYPOTHESIS: retail does not cause wholesale price	C. NULL HYPOTHESIS: retail does not cause wholesale price
° Unidirectional Test: $F_{5,8} = 0.98$*	° Unidirectional Test: $F_{8,8} = 0.35$*
D. NULL HYPOTHESIS: wholesale does not cause retail price	D. NULL HYPOTHESIS: wholesale does not cause retail price
° Unidirectional Test: $F_{5,8} = 0.57$*	° Unidirectional Test: $F_{8,8} = 1.87$*

*Fail to reject null hypothesis at the .10 level.

Summary of Monthly and Quarterly Causality Results

The findings of the Granger, Sims, and Haugh-Pierce procedures on the monthly data for both size classes suggested in general that upward unidirectional causality exists between the three market levels such that ex-vessel causes wholesale price and wholesale causes retail price. An exception to this generalization is the relationship implied by the findings for the Sims and Haugh-Pierce test on the ex-vessel/ wholesale price interface for the 21-25 size class, where the Haugh-Pierce test found no unidirectional causality and the Sims test found feedback. The Haugh-Pierce test indicated instantaneous causality exists that between ex-vessel and wholesale prices for both size classes, however, instantaneous causality was found between the wholesale and retail prices only for the 31-40 size class. The same set of tests using quarterly data for both size classes found no evidence of unidirectional causality between the price series representing any two adjacent market levels. The Haugh-Pierce test suggested that ex-vessel, wholesale, and retail prices are instantaneously related only. These monthly and quarterly causality results are summarized in Table 11.

These findings indicate that the price determination process is recursive from ex-vessel to retail market levels on a monthly basis and simultaneous on a quarterly basis. Thus, the monthly price determination process may be dominated by changes in supplies, with not enough time being allowed for retail factors to play an important part in determining prices. However, the quarterly time period allows enough time for feedback of market signals to occur between retail, wholesale, and ex-vessel market levels, resulting in an interdependent process of price determination.

Table 11: Summary of Monthly and Quarterly Causality Tests Using Ex-vessel (E), Wholesale (W), and Retail (R) Price Data by Size Class.

Null Hypothesis[b]	Test[a]					
	Haugh-Pierce		Granger		Sims	
	31-40	21-25	31-40	21-25	31-40	21-25
			(Monthly Data)			
E<-/->W	R	R				
E -/->W	R	F	R	R	R	R
W -/->E	F	F	F	F	F	R
W<-/->R	R	F				
W -/->R	R	R	R	R	R	R
R -/->W	F	F	F	F	F	F
			(Quarterly Data)			
E<-/->W	R	R				
E -/->W	F	F	F	F	F	F
W -/->E	F	F	F	F	F	F
W<-/->R	R	R				
W -/->R	F	F	F	F	F	F
R -/->W	F	F	F	F	F	F

[a]Reject (R) and fail to reject (F) the null hypothesis.

[b]No unidirectional causality indicated by -/->, which reads "does not cause", and no instantaneous causality indicated by <-/->.

CHAPTER VI
EMPIRICAL RESULTS--PRICE AND MARGIN MODELS

Price dependent monthly and quarterly demand equations were estimated using ordinary least squares and three stage least squares methods. The variables found in each expression were dictated by the theoretical model presented in Chapter II and the impluse response functions derived from the causality analysis presented in Chapter V. However, certain lagged price variables were either included or eliminated based on a set of diagnostic checks and pretesting procedures, both of which are discussed in Appendix B. The criteria determining whether single equation or systems estimation methods were used are also presented in Appendix B.

As with the causality tests, monthly and quarterly data were used for both the 31-40 and 21-25 size classes. The monthly and quarterly models utilized data for the years 1972 through 1981. Estimates of the monthly models by size class are presented first, followed by quarterly model estimates.

Monthly Data

The structural models of monthly retail, wholesale, and ex-vessel demand were estimated using ordinary least squares methods. This method is justified given the generally recursive nature of the price determination process as indicated by the monthly causality analysis. A major hypothesis to be tested with the monthly models was the existence

of asymmetrical price response between market levels. At present, methods to test these hypotheses require recursive expressions. The recursive structure of the retail, wholesale, and ex-vessel demand for the 31-40 size class lend themselves well to testing for asymmetry. For the 21-25 size class, however, only the wholesale/retail market interface was characterized by recursivity, while the ex-vessel/wholesale market interface was characterized by simultaneity. Therefore, in order to perform the test of asymmetry, only the retail demand expression was estimated for the 21-25 size class. Discussion emphasizes estimates that were significant at least at the .25 level.

The 31-40 Size Class

Price models for retail, wholesale, and ex-vessel market levels are presented. Given that the causal direction for monthly prices is upward, only the retail and wholesale price models are presented in asymmetric form.

Retail structural estimates

Empirical estimates of the parameters and corresponding standard errors for the retail price model are given as

$$R_t = \underset{(.920)}{1.023} + \underset{(.040)_1}{.907}\ R_{t-1} + \underset{(.117)_1}{.329}\ W_t - \underset{(.136)}{.111}\ W_{t-1} - \underset{(.063)_2}{.105}\ W_{t-4} + \underset{(.044)}{.042}\ FW_t$$

$$+ \underset{(.0013)}{.00086}\ RDY_t + \underset{(.0037)}{.0036}\ TCFF_t + \underset{(.0017)_3}{.0020}\ CPI_t$$

where the values in parentheses are standard errors and the subscripts 1,2, and 3 refer to significance at the .01, .10 and .25 level of confidence. The model explained approximately 99 percent (R^2 = .9893) of the monthly variation in retail price. Four of the nine estimated coefficients were statistically significant at the .25 level or greater.

The significance of the parameter estimate representing retail price lagged one period (R_{t-1}) indicates that factors which cause a one cent change in retail price (R_t) have a further effect in the same direction of .91 cents in the following period. Thus, virtually the full impact of a change in retail price in a given period is passed on to retail price in the next period. The lagged retail price variable was included to account for first order serial correlation in the error terms for the retail price equation. Given that decision variables such as real disposable income (RDY_t) and the price index for competing meat products (CPI_t) are very stable across months, price in the previous periods may be a very important decision variable for developing expectations needed to establish price in the current period. The significant parameter estimate for R_{t-1} supports this logic. The inclusion of the lagged dependent variable reduced the errors to white noise (Appendix Table B).

The absence of asymmetric responses of current retail price to changes in current wholesale price is indicated by the insignificant parameter estimated for falling current wholesale price (FW_t). The insignificance of the asymmetric parameter estimate causes the parameter estimate on the current wholesale price variable (W_t) to be interpreted as a symmetric test on current wholesale price (FW_t). The insignificance of the asymmetric parameter estimate causes the parameter estimate on the current wholesale price variable (W_t) to be interpreted as a symmetric test on current wholesale price. The estimate for W_t was significant and indicates that as current wholesale price changes by one cent current retail price changes by .33 cents in the same direction. The estimates for the parameters of wholesale price lagged one and four

periods (W_{t-1} and W_{t-4}) are symmetric tests. A one cent change in wholesale price was found to change retail price in the opposite direction by .11 cents four periods in the future, as indicated by the significant estimate at the .10 level for the W_{t-4} parameter. The estimate for W_{t-1} was insignificant.

The more traditional shifters of primary demand, such as real disposable income, total retail supply ($TCFF_t$) and price of competing meat products were generally found to not have a large impact on retail price. A one unit change in the substitute price index, which was proxied by the consumer price index for meat and poultry, caused retail price to change in the same direction by .2 cents, as indicated by the estimate on the parameter CPI_t which was significant at the .25 level. However, this weak significance may simply be due to correlation over time between the retail price for shrimp and the retail price for other meat products. Just how sensitive the consumption of meat and poultry is to changes in the price of shrimp products is questionable, particularly when the per capita consumption of read meat and poultry of 203.5 pounds for 1982 is compared to the consumption in edible meat weight of all shrimp products of 1.53 pounds in 1982 (Food Consumption Prices, and Expenditures 1962-1982, 1983; Fisheries of the United States, 1983). The parameter estimates for real disposable income and total retail supply were found to be insignificant.

Wholesale structural estimates

Empirical estimates of the parameters and corresponding standard errors for the wholesale price model are given as

$$W_t = \underset{(.139)_2}{.289} + \underset{(.059_1)}{.687}\, W_{t-1} + \underset{(.045_1)}{.709}\, P_{t-1} - \underset{(.071_1)}{.372}\, P_{t-1} - \underset{(.030)}{.024}\, FP_t$$

$$- \underset{(.0007)_1}{.0016}\, BSFF_t + \underset{(.0221)}{.0167}\, I31_t - \underset{(.0026)}{.0020}\, OI_t - \underset{(.0011)}{.0008}\, TMCI_t$$

where the values in parentheses are standard errors and the subscripts 1 and 2 refer to significance at the .01 and .05 level of confidence. The model explained approximately 99 percent (R^2 = .9937) of the monthly variation in wholesale price. Five of the nine estimated coefficients were statistically significant at the .05 level or greater.

The significance of the estimated parameter representing wholesale price lagged one percent (W_{t-1}) indicates (as did the analogous estimate in the retail price expression) that factors which cause a change in wholesale price (W_t) have an effect on wholesale price in the next period. Specifically a one cent change in wholesale price causes wholesale price in the next period to change in the same direction by -.69 cents. This is indicated by the estimate of the parameter W_{t-1} being significant at the .05 level. In addition, the lagged dependent variable was included due to the presence of first order serially correlated errors. With the inclusion of this lagged dependent variable, the residuals reduced to an approximate white noise process (Appendix Table B).

Asymmetry was found not to characterize the price response relationship between current ex-vessel (P_t) and current wholesale prices. This is indicated by the estimate of current falling ex-vessel price being insignificant (null hypothesis of zero value not rejected using a one-tailed test). Thus, the estimate on current ex-vessel price reverts to a test of symmetric price response between ex-vessel and wholesale prices, which was found to be significant at the .05 level. This

estimate shows that a one cent change in ex-vessel price causes current wholesale price to change by .71 cents in the same direction. This represents an elasticity of price transmission derived at the means between ex-vessel and wholesale price of .60. Thus, current wholesale and ex-vessel price appear to follow one another closely. This relationship was not found to characterize current wholesale and retail prices.

Increases in the beginning inventories of all raw-headless shrimp ($BSFF_t$) had a significant impact on current wholesale price. Specifically, a one million pound increase in the level of beginning inventories decreases wholesale price by .16 cents. This estimate contrasts to values found by Doll (.82) on an annual basis and Thompson and Roberts (.52) on a monthly basis. An annual study by Hopkins et al. found beginning inventories had no significant effects on wholesale price.

The parameter estimates corresponding to imports of own-size product ($I31_t$) and imports of all other sizes of shrimp (OI_t) were found to be not significantly different from zero. This finding is corroborated somewhat by annual studies done by Hopkins et al. and Doll on the response of wholesale price to changes in the level of total imports. Thompson and Roberts, however, did find a significant inverse relationship between imports and wholesale price.

Wholesale price did not possess a significant relationship with marketing costs, as indicated by the insignificant coefficient estimate for the index of marketing costs represented by $TMCI_t$. The variable $TMCI_t$ served as a proxy for costs of marketing and processing shrimp products incurred at the wholesale level. However, this index was

actually defined as an index for intermediate costs in the processing of more traditional agricultural commodities and may be a relatively poor proxy for cost incurred in seafood wholesaling and processing. The disaggregated components of $TMCI_t$ were also tested, such that parameters for individual indexes could be estimated for labor, packaging and transportation costs. These estimates for component indexes were also found to be insignificant, possibly due to a high degree of multicolinearity between the individual series of data for each index.

Ex-vessel structural estimates

Empirical estimates of the parameter and corresponding standard errors for the ex-vessel price model are given as

$$P_t = \underset{(.065)_2}{.131} + \underset{(.030)_1}{.935}\, P_{t-1} - \underset{(.003)_2}{.0084}\, OL_t - \underset{(.011)_3}{.016}\, L31_t + \underset{(.0005)}{.0008}\, TMCI_t$$

where the values in parentheses are standard errors and the subscripts 1, 2, and 3 refer to significance at the .01, .05, and .20 level of confidence. The model explained approximately 96 percent (R^2=.9642) of the monthly variation in ex-vessel price. Four of the five estimates were statistically significant at the .20 level of confidence or greater.

The significant parameter estimate for ex-vessel price lagged one period (P_{t-1}) indicates that the factors which cause current ex-vessel (P_t) price to change by one cent, result in ex-vessel price in the next period to be further affected in the same direction by .94 cents. Thus, virtually the full impact of a current ex-vessel price change is passed on to ex-vessel price in the next period. As with the retail and wholesale price equation, the lagged dependent variable was included due

to the presence of first order serially correlated errors. However, inclusion of the lagged dependent variable did not remove the serial correlation from the error terms.

Ex-vessel price was significantly affected by quantity landed, both in terms of own-size landings and total landings of other sizes of shrimp. The estimated coefficient for total landings of all other sizes of shrimp (OL_t) indicates that as these landings increase by one million pounds ex-vessel price will decrease by .84 cents. This value contrasts to similarly defined estimates by Doll (.32 cents) and Thompson and Roberts (.56 cents). The estimated coefficient for own-size landings ($L31_t$) indicates that as landings of only 31-40 count shrimp increases by one million pounds, ex-vessel price decreases by 1.6 cents. However, ex-vessel price for the 31-40 size class appears to be more sensitive to total landings of all other sized shrimp than to landings of shrimp in the 31-40 size class. This is illustrated by the price flexibilities derived at the means for the parameters OL_t and $L31_t$ of .036 and .013, respectively. The parameter estimate for the marketing cost index $TMCI_t$ was found to have a small standard error relative to the estimated coefficient, but possessed the wrong sign. Input costs of processing raw product were hypothesized to have an inverse relationship with the demand for raw product. Thus, on the basis of a one-tailed test, the estimate was found to be insignificant. As with the wholesale model, the costs of intermediate goods and services used in manufacturing food products had no significant impact on the determination of price.

The 21-25 Size Class

Only the price model for the retail market level is estimated. This was because the retail/wholesale market level interface was recursive. The wholesale/ex-vessel market level interface was characterized by simultaneity. This limitation on the models presented is warranted due to the necessity of performing the asymmetry test, which does not lend itself to non-recursive methods.

Retail structural estimates

Empirical estimates of the parameters and corresponding standard errors for the retail price model are given as

$$R_t = \underset{(.952)}{.342} + \underset{(.039)_1}{.851}\, R_{t-1} + \underset{(.085)}{.066}\, W_t + \underset{(.127)_2}{.210}\, W_{t-1} - \underset{(.088)}{.105}\, W_{t-2}$$

$$- \underset{(.035)}{.027}\, FW_t - \underset{(.0013)}{.0007}\, RDY_t - \underset{(.0042)_2}{.0069}\, TCFF_t + \underset{(.0016)_2}{.0029}\, CPI_t$$

where the values in parentheses are standard errors and the subscripts 1 and 2 denote significance at the .01 and .10 level of confidence. The model explained approximately 99 (R^2=.9897) percent of the variation in retail price. Four of the eleven estimates were statistically significant at the .25 level or greater.

The significant positive parameter estimate for retail price lagged one period (R_{t-1}) again indicates that factors which affect current retail price (R_t) have a further impact on price in the next period. Specifically, a one cent change in retail price causes a .85 cent change in retail price in the following period. The lagged dependent variable was included to account for first order serial correlation in the error terms. The inclusion of this term reduced the error terms to white noise.

The response relationship between retail and wholesale prices is characterized by symmetry. The parameter estimate for current falling wholesale price is insignificant, indicating that symmetry exists. Given that the coefficient estimate for current wholesale price is insignificant, the coefficient estimate for current wholesale price (W_t) is tested for significance under the assumption of symmetric response of retail price to increasing or decreasing wholesale price. Current wholesale price was found to not have a significant impact on the determination of current retail price. Wholesale price lagged one period (W_{t-1}) had a significant impact on current retail price. A one cent change in wholesale price was found to change retail price in the next period by .21 cents in the same direction. However, a change in wholesale price by one cent was shown to not cause a significant change in retail price two periods later.

The primary demand shifters included in the 21-25 size class model, such as real disposable income (RDY_t), retail supply ($TCFF_t$), and price index of competing meat products (CPI_t), were found to be somewhat more important in determining current retail price than for the 31-40 size size class model. The retail supply of all size classes of raw-headless shrimp and the proxy for the substitute price of other meats were both significant at the .10 level of confidence. A one million pound change in the retail supply will cause a .7 cent change in current retail price in the opposite direction. The sign is as that expected if the $TCFF_t$ is interpreted as capturing a supply effect. A one unit change in the consumer price index for meat and poultry causes a significant .3 cent change in retail price in the same direction. This suggests that as the price of meats and poultry increases, shrimp appears to be substituted

for these two products, thus increasing the demand for shrimp and eventually bidding up the price for shrimp products. Due to the relatively small percentage share that shrimp accounts for in the per capita consumption of meat, poultry, and fish, however, the measured impact may be simply the correlation over time between the prices of shrimp and other meat products. The parameter estimate for real disposable income was not found to be statistically significant. Thus, real income has little effect on the determination of retail price of either size class on a monthly basis. This is verified by simply observing the data over the time period of the analysis (1972-1981)--prices have fluctuated as real disposable income remained relatively stable. Finally, the constant term was also found to be insignificant.

Quarterly Data

Structural expressions for quarterly retail, wholesale, and ex-vessel demand are estimated using the three stage least squares method. This approach is warranted due to (1) the simultaneous nature of the price relationships found in the causality results for the quarterly data and (2) the presence of significant contemporaneous cross correlation of the residuals from two stage least squares analysis of the simultaneous system. Once the structural estimates of the coefficients are obtained, derived reduced form parameters are calculated. In addition, the presence of lagged dependent variables in the reduced form expressions necessitates the derivation of the final form estimates of the parameters. These final form estimates are then used to construct margin expressions in terms of the full set of exogenous variables of the structural model. Final form expressions are computed for both 31-

40 and 21-25 size class shrimp. The results are discussed by size class in terms of initial structural, reduced form and final form estimates and final form margin estimates. Tests for asymmetry were not performed due to the simultaneous nature of the quarterly models and the fact that asymmetry tests require recursiveness.

As pointed out by Christ (1966) and Kmenta (1971), conventional tests of statistical significance; i.e. t-statistics, are not valid for most simultaneous estimation procedures. This is particularly true for small sample studies such as the present study. Thus, the discussion of the findings from the quarterly analysis emphasizes all estimates possessing the anticipated sign, regardless of the relative sizes of a given parameter estimate and the corresponding standard error as found in the initial structural estimation. In the analysis of quarterly data, the structural estimates represent only partial effects; i.e., the impact of a predetermined variable only on the level, or structure, in the market for which it has a direct effect. The reduced and final form estimates provide, in addition, the indirect effects on the other market levels.

The 31-40 Size Class

Price models for retail, wholesale, and ex-vessel market levels are presented, in terms of the structural, reduced form, and final form parameter estimates. The structural model had a system R^2 of .9660. Final form expressions for retail/wholesale and wholesale/ex-vessel margins are also discussed.

Retail structural estimates

Empirical estimates of the parameters and corresponding standard errors for the retail price model are given as

$$R_t = \underset{(1.021)}{.370} + \underset{(.108)}{.556}\, W_t + \underset{(.060)}{.629}\, R_{t-1} - \underset{(.0016)}{.0024}\, RDY_t + \underset{(.0044)}{.0023}\, TCFF_t + \underset{(.0036)}{.0094}\, CPI_t$$

where the values in parentheses are standard errors. Four of the six estimated coefficients possess the anticipated sign.

The parameter estimate for current wholesale price (W_t) indicates that as current wholesale price changes by one cent, retail price (R_t) changes by .56 cents in the same direction. This corresponds to an elasticity of price transmission at the means between current wholesale and retail price of .39. Thus, current retail price is inelastic to changes in current wholesale price. A one cent change in retail price was shown to have a further effect on retail price in the next period. This is apparent when considering the coefficient associated with R_{t-1}, which was included due to the error terms being first order serially correlated. The coefficient estimates for retail price lagged one period (R_{t-1}) indicate that factors which cause retail price to change by one cent caused retail price to experience further change in the same direction of .63 cents in the next period. This "carry-over" effect represents an elasticity of price transmission between lagged and current retail price of .62. The cumulative impact of the current and lagged price will be evident in the final form analysis which is discussed later.

The primary demand shifters income (RDY_t), retail supply ($TCFF_t$), and price of competing meat products (CPI_t) were, as in the monthly models for the 31-40 size class, not as a group very important determinants of retail price. The estimated coefficient for the variable CPI_t indicated that a one unit change in the consumer price index for meat and poultry will result in a .94 cent change in retail price of

shrimp as shrimp is a substitute for relatively higher priced substitutes. This estimate, however, may simply be capturing the positive correlation over time between the prices of raw-headless shrimp and competing meat products. The estimated coefficient on the income parameter RDY_t has the wrong sign and is, thus, insignificant. In addition, the estimated coefficient on the supply variable $TCFF_t$ was expected to have a negative sign, indicating that as the quantity supplied changes, retail price should change in the opposite direction. The estimated coefficient, however, has a positive sign. This same finding of insignificance was found for the monthly retail model.

Wholesale structural estimates

The empirical estimates of the parameters and the corresponding standard errors for the wholesale price model are given below as

$$W_t = \underset{(.173)}{.247} - \underset{(.137)}{.051}\, R_t + \underset{(.093)}{1.110}\, P_t + \underset{(.093)}{.041}\, R_{t-1} - \underset{(.0015)}{.0011}\, BSFF_t$$

$$+ \underset{(.0016)}{.0001}\, OI_t - \underset{(.0129)}{.0036}\, I31_t + \underset{(.00081)}{.00033}\, TMCI_t$$

where the values in parentheses are the standard errors. Seven of the eight estimated coefficients possess the anticipated sign.

Current wholesale price was shown to be very sensitive to changes in current ex-vessel price (P_t). The estimated coefficient for ex-vessel price shows that as ex-vessel price increases by one cent, wholesale price increases by 1.1 cents. This translates into an elasticity of price transmission at the means between current ex-vessel and wholesale price of .932. An elasticity of price transmission less than one in describing the response of wholesale price to an ex-vessel price

seems plausible. The cost of the raw product, of course, represents a smaller percentage of the wholesale price than of the ex-vessel price, due to value added through processing and wholesaling. A percentage change in the raw product price should result in a smaller percentage change in total price at the wholesale than at the ex-vessel level. However, given that the product form under scrutiny is raw-headless shrimp, which actually requires little further processing, the percentage change in wholesale given a change in ex-vessel price should be close to 1.0. In addition, price differences attributable to time and space dimensions are largely represented by the cost of holding inventory and transportation, which represent a relatively small percentage of wholesale price (Penn, 1980; Hu, 1983).

Retail price lagged one period (R_{t-1}) had a small positive impact on current wholesale price. Specifically, a one cent change in retail price will have a .04 cent change in the same direction in wholesale in the next period. The positive estimate may be describing the positive effect on the derived demand for wholesale product given changes in the demand at the retail level in the previous period. Current retail price appears to have an insignificant impact on current wholesale price as indicated by the negative coefficient estimate for the retail price parameter and the relatively large standard error. However, a positive relationship between current retail and wholesale price was expected. This finding, coupled with the relationship between retail and wholesale prices as shown in the quarterly retail model, suggests that retail price is more sensitive to changes in wholesale price than wholesale price is to changes in retail price.

The estimated coefficients for the quantity variables given as beginning inventories of raw-headless shrimp ($BSFF_t$) and imports of raw-headless shrimp of the 31-40 size class ($I31_t$) have the expected sign although the level of statistical significance is questionable due to large standard errors. A one million pound change in beginning inventories will change wholesale price in the opposite direction by .11 cents. The estimate may be describing the relationship between inventories and wholesale price where inventories which are built up disproportionately during the first and fourth quarters due to imports are released into the market system. A one million pound change in own-size imports ($I31_t$) results in wholesale price changing in the opposite direction by .36 cents. Wholesale price is more sensitive to changes in beginning inventories of raw-headless shrimp than changes in imports of 31-40 count shrimp. This is indicated by the flexibilities of -.022 and -.004, computed at the means of wholesale price to changes in beginning stocks and own-size imports, respectively. The estimated coefficient for total imports of all other size classes of raw-headless shrimp (OI_t) did not have the anticipated sign. A positive relationship between other size imports and wholesale price for a given size class may have two possible explanations. First, as price of other size classes increases, the quantity supplied of other size classes may increase. Secondly, over the last ten years, imports and prices have increased simultaneously, because of relatively large demand increases concurrent with positive supply shifts.

Wholesale price is positively related to costs of intermediate goods and services. Specifically, a one unit change in the index of these processing and wholesaling costs results in a wholesale price

change in the same direction of .03 cents. A flexibility estimate of .02 suggests wholesale prices are not highly dependent on changes in marketing costs. This low estimate may reflect the inappropriateness of using an aggregate cost index for processing and wholesaling general agricultural commodities in estimating the response of prices for raw-headless shrimp to changes in marketing costs. In addition, the quarterly time period, as may be true for the monthly data, may not be a long enough sampling interval over the time period of the analysis to detect significant changes in general input cost levels.

<u>Ex-vessel structural estimates</u>

Empirical estimates of the parameters and the corresponding standard errors for the ex-vessel price model are given as

$$P_t = \underset{(.075)}{-.129} + \underset{(.033)}{.906}\,W_t - \underset{(.00097)}{.00011}\,OL_t - \underset{(.0024)}{.0027}\,L31_t - \underset{(.00055)}{.00025}\,TMCI_t$$

where the values in parentheses are standard errors. All estimates have the expected sign.

Ex-vessel price was found to be very sensitive to changes in wholesale price. The estimated coefficient for W_t indicates that a one cent change in current wholesale price will result in a .91 cent change in current ex-vessel price. This corresponds to a flexibility estimated at the means of 1.08. Thus, ex-vessel price is slightly flexible to changes in wholesale price. Given the estimate for P_t in the wholesale model, ex-vessel and wholesale price are major determinants of each other in a given quarter. Market conditions in the producer/first handler and wholesale market are not only important to own price determination, but also important to price determination in the adjacent

market. This relationship is not nearly as strong between retail and wholesale market levels.

The coefficient estimates for own-size landings ($L31_t$) and total landings of all other size classes (OL_t) are shown to be inversely related to ex-vessel price. A one million pound change in landings of 31-40 count shrimp results in current ex-vessel price changing in the opposite direction by .2 cents. A one million pound change in total landings of other-size shrimp causes ex-vessel price to change in the opposite direction by .01 cents. These structural estimates for own-size and other size landings correspond to flexibility estimates of -.007 and -.003, respectively. Thus, ex-vessel price is very inflexible to quantity landed. However, ex-vessel price is more sensitive to own-size landings than to total landings of other size classes.

Ex-vessel price was found to be inversely related to the costs of intermediate goods and services in the wholesaling and processing sector. The estimated coefficient for the parameter $TMCI_t$ indicated that as the index that represents these cost changes by one unit, ex-vessel price changes in the opposite direction by .03 cents. If these costs more nearly represent costs incurred at the wholesale level, theory would suggest that, as costs increase, derived supply (wholesaler supply to retailer) would shift up and derived demand (wholesale demand for producer raw product) would shift down, thereby causing wholesale prices to increase and producer (ex-vessel) prices to decrease (Tomek and Robinson, 1972). The findings for the 31-40 size class wholesale and ex-vessel price models regarding the $TMCI_t$ variable lend support to the theory. These findings, however, are questionable due to the relatively large standard error associated with the parameter

estimate. In addition, $TMCI_t$ is at best only a proxy for the cost of inputs associated with wholesaling and processing raw-headless shrimp.

Reduced and final form estimates

The reduced form and final form coefficient and price flexiblity estimates corresponding to the structural coefficient estimates for the retail, wholesale, and ex-vessel price models were derived. The reduced and final form estimates of the structural system describe each jointly determined variable in terms of all predetermined variables. This differs from the structural equations in that each structural equation attempts to describe a specific part of the system being modeled in a ceteris paribus fashion, while also taking into account all of the interdependencies among the jointly determined variables. In addition, structural estimates are only derived for varibles directly involved in the part of the system represented by a given equation. Structural estimates and reduced and final form estimates are measures of change in the jointly determined variable given a change in a predetermined variable. The structural estimate, however, assumes all other predetermined variables are constant in the current time period (partial effect), while reduced and final form estimates represent an equilibrium after all variables have been allowed to change. When lagged dependent variables are present, the reduced form estimates are essentially an intermediate result, since effects of the lagged variables have not been allowed enough time to work through the system. In this case, final form estimates would be more appropriate for analysis. Lagged endogenous variables (prices) exist in this study. Thus, the reduced forms are presented only in Appendix D. The following discussion is oriented toward the final form estimates.

The final form coefficients found in Table 12 provide the long-run impact of changes in the full set of predetermined variables on each jointly determined variable. The term "long-run" implies that enough time has elapsed such that the effects of all lagged variables have been taken into account. For the model representing the 31-40 size class, only a lag of one quarter was necessary. The values are of the same sign, but generally larger than the reduced form estimates, reflecting the cumulative effect of the lagged term which is incorporated in the estimate. In addition, the flexibility estimates are relatively larger than the reduced form flexibilities.

The retail final form estimates are larger than either the wholesale or ex-vessel estimates. The latter of the two are very close in value which reflects the close dependency between the ex-vessel and wholesale market levels found in the initial structural model. Exceptions are the estimate for RDY_t, $TCFF_t$, and CPI_t. The estimates for RDY_t and CPI_t, however, are insignificant based on the sign. The flexibility estimates are generally larger for the ex-vessel level than for either retail or wholesale levels. With the exception of $TCFF_t$, however, the flexibility estimates are close in value. Flexibility estimates are not computed for CPI_t and $TMCI_t$ since these variables are already expressed in terms of percentages. The signs on the final form estimates are generally the same as found at the structural level, with the exception of $TCFF_t$ and CPI_t. In the longer-run, $TCFF_t$ appears to pick up the impact of retail supply.

Table 12: Final Form Coefficients and Flexibility Estimates for the Retail, Wholesale and Ex-vessel Price Models for the 31-40 Size Class.

Jointly Determined Variables	Predetermined Variables								
	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I21_t$	OL_t	$L21_t$	$TMCI_t$
R_t	.0039[a] (.8750)[b]	-.0038 (-.0780)	.0151	-.1770 (-2.493)	.0211 (.2970)	-.5803 (-.4600)	-.0178 (-.1410)	-.4829 (-.6850)	.0086
W_t	.0069 (2.2070)	-.0067 (-.1970)	-.0270	-.1180 (-2.3680)	.0140 (.2810)	-.3866 (-.4370)	-.0119 (-.1340)	-.3219 (-.6500)	.0157
P_t	-.0063 (2.4010)	-.0060 (-.2110)	-.0245	-.1069 (-2.5570)	.0127 (.3040)	-.3503 (-.4720)	-.0108 (-.1450)	-.2942 (-.7090)	.0048

[a]Estimated final form coefficient.

[b]Estimated flexibility derived at the means.

Margin estimates

The margin expressions representing retail/wholesale and wholesale/ex-vessel price spreads were derived from the final form estimates for each market level (Table 13). The values in parentheses are the derived flexibility estimates. Note that flexibilities are not shown for CPI_t and $TMCI_t$ since these terms are already percentage values. Each estimate for the quarterly margins was obtained by subtracting the corresponding estimates predetermined variable from each price model. The indicated margin flexibilities were derived at the means after the estimates were obtained. The estimated coefficients of the margin expression were generally of the same sign found for the corresponding parameter estimates in the final form expressions. The estimates for the retail/wholesale margin were typically larger than for the wholesale/ex-vessel margin, which reflects the increasingly larger marketing cost at the retail level. In addition, the margin flexibility estimates derived are larger for the retail/wholesale margin than for the wholesale/ex-vesel margin. This finding supports the structural, reduced form, and final form analysis regarding basic relationships between the three market levels. For example, retail and wholesale price have been shown to be relatively unresponsive to changes in each other as shown in the monthly and quarterly price analysis. Thus, changes in retail price are not fully passed to wholesale price, and vice versa. This relationship does not characterize wholesale and ex-vessel market levels. The retail/wholesale margin, therefore, could be expected to be relatively more flexible to changes in market conditions as compared to the wholesale/ex-vessel margin.

Table 13: Final Form Margin Estimates and Flexibilities for the Retail/Wholesale (M^{rw}) and the Wholesale/Ex-vessel (M^{wp}) Margins for the 31-40 Size Class.

Margin	Predetermined Variables								
	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I21_t$	OL_t	$L21_t$	$TMCI_t$
M^{rw}	-.0030[a] (-2.259)[b]	.0029 (.200)	.0119	-.0590 (-2.788)	.0071 (.336)	-.1937 (-.515)	-.0059 (-.157)	-.1610 (-.766)	.0029
M^{wp}	.0006 (1.192)	-.0007 (-.127)	-.0025	-.0111 (-1.384)	.0013 (.162)	-.0363 (-.255)	-.0011 (-.077)	-.0277 (-.348)	.0009

[a]Final form margin estimate.

[b]Flexibility derived at the means.

The estimated coefficients for real disposable income (RDY_t), total retail supply ($TCFF_t$), and price index of competing meat products (CPI_t) indicate that these variables have mixed impacts on the margins. Real disposable income appears to be insignificant. This finding reflects insignificant changes in disposable income over the period analyzed. Total retail supply and price index of competing meat products have a positive impact on M^{rw} but a negative impact on M^{wp}. Attempts to draw conclusive inferences from these inconsistent findings appears questionable.

The coefficients for beginning inventories ($BSFF_t$) and own-size imports ($I31_t$), which originally were found in the wholesale price model, indicate that the margins are inversely related to beginning inventories of raw-headless shrimp and imports of 31-40 size class raw-headless shrimp. A one million pound increase in $BSFF_t$ and $I31_t$ results in a 5.9 and 19.4 cent decrease, respectively, in M^{rw} and a 1.1 and 3.6 cent decrease, respectively, in M^{wp}. However, each margin was found to be more sensitive to change in beginning inventories than to imports of the 31-40 size class, as the flexibilities indicate. Specifically, a one percent increase in $BSFF_t$ decreased M^{rw} and M^{wp} by 2.79 and 1.38 percent respectively. This compares to a decrease of .52 and .26 percent in M^{rw} and M^{wp}, respectively, given a one percent increase in $I31_t$.

Landing of own-size shrimp ($L31_t$) and total landings of all other size shrimp (OL_t) were found to be inversely related and inflexible to each margin. Specifically, a one million pound increase in other landings and own-size landings was shown to decrease M^{rw} by .59 and 16.10 cents, respectively. The same change was shown to decrease M^{wp} by

.11 and 2.77 cents, respectively. In addition, a one percent increase in other-size and own-size landings decreases M^{rw} by .157 and .766 percent, respectively. The same changes would decrease M^{wp} by .077 and .348 percent, respectively. The inverse relationship between the quantity variables and both margins may suggest, as was found with the monthly margin expressions, that economies of size in terms of quantity handled may exist for retailers, wholesalers, and first-handlers. The inverse price effect attributed to changes in quantities appears to have a much larger impact on the more volatile retail/wholesale margin.

Both margins were found to be positively related to increases in intermediate food marketing costs ($TMCI_t$). Specifically, a one unit increase in $TMCI_t$ was found to increase M^{rw} and M^{wp} by .29 and .09 cents, respectively. Thus, the retail/wholesale margin was more sensitive than the wholesale/ex-vessel margins to changes in marketing costs.

The 21-25 Size Class

Price models for retail, wholesale, and ex-vessel market levels are presented in terms of the initial structural, reduced form, and final form parameter estimates. This is in contrast to the analysis of monthly data where only the asymmetric retail price model was estimated. The structural model had a weighted system R^2 of .966. Final form margin expressions are also discussed.

Retail structural estimates

The empirical estimates of the parameters and corresponding standard errors for the retail price model are given as

$$R_t = \underset{(1.185)}{.145} + \underset{(.092)}{.477}\, W_t + \underset{(.056)}{.708}\, R_{t-1} - \underset{(.0018)}{.00037}\, RDY_t - \underset{(.0048)}{.0036}\, TCFF_t + \underset{(.0033)}{.0020}\, CPI_t$$

where the values in parentheses are the standard errors. All but one of the coefficient estimates are of the anticipated sign.

Current retail price (R_t) was found to be positively related to current wholesale price (W_t) and retail price lagged one period (R_{t-1}). A one cent change in current wholesale price caused current retail price to change in the same direction by .48 cents. This represents an elasticity of price transmission of .34. Current retail price was thus found to be inelastic to changes in current wholesale price. A one cent change in retail price was shown to have a further positive effect on retail price in the next period. As in the case of retail price estimation for the 31-40 size shrimp, R_{t-1} was included to account for first order serially correlated error terms in the retail model. However, the coefficient for R_{t-1} can be interpreted such that factors which cause a one cent change in retail price cause further change in retail price in the next period of .71 cents. This lagged effect for the 21-25 size class is slightly greater than the comparable value of .63 found for the 31-40 size class. In terms of the elasticity of price transmission between lagged and current retail price, a one percent change in retail price has a .70 percent change in retail price next period in the same direction.

Estimates for two of the three retail demand shifters included in the retail demand model were of the anticipated sign. However, the indicated impact on retail price was found to be small. A one million pound change in total retail supply of raw-headless shrimp changes retail price in the opposite direction by .36 cents. This represents a flexibility estimate of -.058. This is in contrast to the insignifiance found for the same variable in the 31-40 size class retail model. A one

unit change in the consumer price index for meat and poultry results in retail price changing in the same direction by .20 cents. This represents a price flexibility of .067. This coefficient may simply be capturing the positive correlation over time between shrimp prices and meat and poultry prices. Retail prices, however, appear to be very inelastic to changes in supply and price of competing meat products. The flexibility estimate for CPI_t derived for the 21-25 size class was much smaller than that derived for the 31-40 size class, which indicates retail price for the 31-40 size class products is much more sensitive to changes in the prices of competing meat products. This observation, of course, assumes that indeed a substitution effect is being captured by the parameter estimate for CPI_t. This contrast in findings for the 21-25 and 31-40 size classes suggests that the smaller shrimp are viewed as less of a luxury item and compete with meat and poultry in a more direct sense for consumer budget expenditures than do the larger, more expensive 21-25 count shrimp. The estimated coefficient on the income parameter RDY_t was found to be of the negative sign and thus assumed to be insignificant. This same negative relationship was found with the 31-40 quarterly retail model. In addition, income was found to be insignificant in the monthly retail price models. This suggests that a monthly or quarterly sampling period is not of sufficient length over the time period of the analysis to capture the relatively stable effect of monthly and quarterly real disposable income on retail demand. However, studies done by Doll (1972), Hopkins et al. (1980), and Cleary (1969) have found real disposable income to be significant on an annual basis.

Wholesale structural estimates

The empirical parameter estimates and the corresponding standard errors of the wholesale price model are given as

$$W_t = \underset{(.202)}{.048} + \underset{(.195)}{.356}\, R_t + \underset{(.131)}{.798}\, P_t - \underset{(.162)}{.300}\, R_{t-1} + \underset{(.052)}{.146}\, W_{t-1}$$

$$- \underset{(.0019)}{.0011}\, BSFF_t + \underset{(.0019)}{.0008}\, OI_t - \underset{(.020)}{.0025}\, I21_t + \underset{(.0010)}{.0015}\, TMCI_t$$

where the values in parentheses are the standard errors. Seven of the nine estimates have the anticipated sign.

Retail price was found to be a more important determinant of wholesale price for the 21-25 size class than for the 31-40 size class. A one cent change in retail price caused current wholesale price to change in the same direction by .36 cents. This one cent change in retail price was shown to not have a further significant effect on wholesale price in the next period, as indicated by the negative estimated coefficient of the parameter R_{t-1}. The estimated elasticity of price transmission between current retail and current wholesale price was found to be .502. Though inelastic, change in retail price was shown to be much more important to the determination of wholesale price for the 21-25 size class product than for the 31-40 size class product.

Ex-vessel price was found to be an important determinant of wholesale price. A one cent change in current ex-vessel price was found to change current wholesale price by .80 cents in the same direction. This elasticity of price transmission indicates that a one percent change in ex-vessel price will change wholesale price in the same direction by .68 percent. Thus, ex-vessel price appears to have a larger impact on wholesale price than does retail price.

Factors which affect current wholesale price were found to have an additional positive impact on wholesale price in the next period. Specifically, given that these factors have caused current wholesale price to change by one cent, the estimated coefficient for W_{t-1} indicates that a further change in wholesale price in the same direction of .15 cents will follow in the next period. However, the carry-over effect is relatively small. The elasticity of price transmission between lagged and current wholesale price was estimated to be .145. Wholesale price lagged one period (W_{t-1}) was originally included due to first order serially correlated errors found for the wholesale price model.

Wholesale price was found to have a negative relationship with beginning inventories of raw-headless product ($BSFF_t$) and imports of raw-headless product ($I21_t$). A million pound change in beginning inventories and imports of 21-25 size shrimp causes wholesale price to change in the opposite direction by .11 and .25 cents, respectively. Total imports of all other sizes of raw-headless shrimp (OI_t) had an insignificant impact on the determination of wholesale price and the wrong sign on the coefficient. This same result was found in the wholesale model for the 31-40 size class and in the monthly analysis. The parameter OI_t may simply be capturing the positive correlation over time between total imports and wholesale price. Wholesale price was anticipated to have a negative relationship with total imports, such that as the total amount of imports increased, wholesale price would be bid down.

Wholesale price was shown to have a positive relationship with the costs of intermediate goods and services in wholesaling and

processing. The estimated coefficient for the cost parameter $TMCI_t$ indicated that a one unit change in the intermediate goods and services index causes wholesale price to change by .15 cents in the same direction. This estimate is much greater than the value of .03 found for the 31-40 size class. Thus, these costs appear to be of greater importance to the wholesale price determination process for the larger size shrimp. This finding may be partially explained by the differing lag structure found in the wholesale price model for each size class. The 21-25 size class wholesale price model included wholesale price lagged one period, whereas the 31-40 size class model did not. The variable W_{t-1} was included due to the presence of first order serially correlated error terms in the wholesale price model in the absence of W_{t-1}. The significant estimated coefficient on the variable W_{t-1} suggests that the larger shrimp do not move through the market as fast as the smaller size shrimp. The larger shrimp, therefore, may be held up in the inventory longer and incur larger interest costs on a per pound basis. With interest cost being a component of the aggregate cost index $TMCI_t$, wholesale prices may be more sensitive to changes in this cost of inventory due to a slower market turnover rate.

Ex-vessel structural estimates

The empirical parameter estimates and the corresponding standard errors of the ex-vessel price model are given as

$$P_t = \underset{(.068)}{.120} + \underset{(.027)}{.861}\, W_t - \underset{(.0011)}{.0011}\, OL_t - \underset{(.0078)}{.0188}\, L21_t - \underset{(.00057)}{.00025}\, TMCI_t$$

where the values in parentheses are the standard errors. All five of the estimated coefficients had the anticipated sign.

Ex-vessel price was shown to have a very strong positive relationship with wholesale price. A one cent change in current wholesale price was found to cause ex-vessel price to change in the same direction by .86 cents. This represents an elasticity of price transmission between ex-vessel and wholesale price of 1.01. This finding is virtually identical to the elasticity value found for the 31-40 size class. Thus, ex-vessel and wholesale prices follow one another very closely when the causal shock originates from wholesale price. As indicated by the smaller estimated coefficient and corresponding elasticity of price transmission for ex-vessel price in the previously discussed wholesale demand model, wholesale prices do not follow ex-vessel price changes as closely.

Both landings of 21-25 size shrimp ($L21_t$) and total landings of all other size shrimp (OL_t) had the anticipated negative relationship with ex-vessel price. A one million pound change in landings of 21-25 shrimp changes ex-vessel price in the opposite direction by 1.88 cents. Whereas a one million pound change in the total landings of all other size classes of shrimp changed ex-vessel price in the opposite direction by .11 cents. This latter effect is only weekly significant. The percentage impact on ex-vessel price is almost twice as large for a percentage change in own-size landings (-.021) as that for other size landings (-.012).

Ex-vessel price was found to be inversely related to costs of intermediate goods and services ($TMCI_t$) A one unit change in the index for the costs of intermediary goods and services causes ex-vessel price to change in the opposite direction by .03 cents. The price flexibility estimate -.02 suggests that ex-vessel price, as was wholesale price, is

very inelastic to changes in these intermediate costs. The findings for the 21-25 size class wholesale and ex-vessel prices regarding $TMCI_t$ are in agreement with the findings of the 31-40 size class models.

Reduced and final form estimates

The reduced form and final form coefficients and price flexibility estimates corresponding to the structural coefficient estimates for the retail, wholesale, and ex-vessel price models were obtained. A review discussion on the definition and general interpretation of reduced and final form estimates was presented for the 31-40 size class analysis and will not be repeated here. Due to the presence of lagged endogenous variables in the retail and wholesale price expressions, the reduced form estimates are intermediate and presented in Appendix D. The following discussion will be oriented toward final form estimates.

The final form estimates indicate the long-run impact that each predetermined variable has at the three market level (Table 14). As with the 31-40 models, a lag of only one period was incorporated into the final form estimates. Retail and wholesale price, however, were both lagged a single quarter for the 21-25 models. The cumulative final form estimates were larger in an absolute sense than the reduced form estimates, reflecting the impact of these additional lag periods. In addition, the final form coefficient estimates and flexibilities for the retail level were found to be larger than the respective estimates at wholesale or ex-vessel levels.

All quantity variables, with the exception of other size imports (OI_t), have the expected negative sign. A one million pound increase in landings of 21-25 count shrimp was shown to decrease retail, wholesale,

Table 14: Final Form Coefficients and Flexibility Estimates for the Retail, Wholesale and Ex-vessel Price Models for the 21-25 Size Class.

Jointly Determined Variables	Predetermined Variables								
	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I21_t$	OL_t	$L21_t$	$TMCI_t$
R_t	-.0028[a] (-.4920)[b]	-.0274 (-.4410)	.0152	-.0239 (-.2630)	.0173 (.1930)	-.0542 (-.0247)	-.0189 (-.1250)	-.3247 (-.2200)	.0273
W_t	-.00094 (-.2330)	-.0092 (-.2090)	.0051	-.0145 (-.2250)	.0106 (.1670)	-.0333 (-.0230)	-.0116 (-.1080)	-.1987 (-.1900)	.0167
P_t	-.00081 (-.2360)	-.0079 (-.2110)	.0044	-.0125 (-.2280)	.0091 (.1690)	-.0286 (-.0230)	-.0111 (-.1220)	-.1900 (-.2130)	.0141

[a]Estimated final form coefficient.

[b]Estimated flexibility derived at the means.

and ex-vessel price by 32.5, 19.9, and 19.0 cents, respectively. The corresponding price flexibilities at the retail, wholesale and ex-vessel levels were -.22, -.19, and -.21, respectively. In a relative sense between predetermined variables, the price flexibility estimates for own-size landings ($L21_t$), beginning stocks ($BSFF_t$), and retail supply ($TCFF_t$) indicated that these parameters have approximately the same impact on price at all three levels. The retail flexibility is slightly higher for the retail supply, indicating a greater sensitivity at the retail level. The estimates for own-size imports ($I21_t$), other-size imports (OI_t) and landings of other-size shrimp (OL_t), indicate that changes in these variables have a relatively smaller impact on prices at each market level. A one-unit change in the marketing cost variable $TMCI_t$ causes a change in the same direction in retail, wholesale, and ex-vessel price of 2.7, 1.7, and 1.4 cents, respectively, which are substantially larger than that estimated for the 31-40 size class. The coefficient estimates at all market levels are positive for the CPI_t variable, indicating substitution between shrimp and competing meat products. Note that flexibilities are not estimated for CPI_t and $TMCI_t$ since these variables are already in percentage terms.

Margin estimates

The margin expressions representing retail/wholesale and wholesale/ex-vessel price spreads were obtained from the final form estimates for the three market levels. The methodology utilized for deriving the coefficient estimates and flexibilities contained in these expressions was the same as that employed in the 31-40 class analysis.

The coefficient estimates and margin flexibilities obtained for the retail/wholesale margins were larger than for the wholesale/ex-vessel margin (Table 15), as was found in the margin analysis for the 31-40 size class prices. This finding appears to result from retail (wholesale) price being relatively unresponsive to changes in wholesale (retail) price, while wholesale and ex-vessel prices follow each other closely, thus allowing a more steady margin between ex-vessel and wholesale price. The 31-40 size class prices were similar in this respect. In addition, retail price is much more sensitive to changes in the predetermined variables than are either wholesale or ex-vessel prices. In fact, the latter two prices are approximately equal in terms of flexibility to changes in each predetermined variable. These two conditions combine to cause the margin between retail and wholesale prices to be more sensitive to changes in the predetermined variables than is the margin between wholesale and ex-vessel prices.

The retail/wholesale margin was found to be relatively sensitive to changes in $TCFF_t$. A one million pound increase in retail supply of raw-headless shrimp of all sizes decreases the margin by 1.8 cents. This estimate corresponds to a margin flexibility estimate of -1.01. This estimate approximates unitary flexibility. In contrast, M^{wp} is not as sensitive to changes in $TCFF_t$. The same shift in $TCFF_t$ produced a -.13 cent change in M^{wp}. This coefficient corresponds to a margin flexibility estimate of only -.199 percent. A one unit change in price index for competing meat products (CPI_t) changes M^{rw} and M^{wp} in the same direction by 1.01 and .07 cents, respectively. Thus, the wholesale/ex-vessel margin is not as sensitive to shifts in factors which determine retail demand. Real disposable income (RDY_t) was found to be

Table 15: Final Form Margin Estimates and Flexibilities for the Retail/Wholesale (M^{rw}) and the Wholesale/Ex-vessel (M^{wp}) Margins for the 21-25 Size Class.

	Predetermined Variables								
Margin	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I21_t$	OL_t	$L21_t$	$TMCI_t$
M^{rw}	-.00186[a] (-1.121)[b]	-.0182 (-1.005)	.0101	-.0094 (-.355)	.0067 (.257)	-.0209 (-.035)	-.0073 (-.166)	-.1260 (-.293)	.0106
M^{wp}	-.00013 (-.217)	-.0013 (-.199)	.0007	-.0020 (-.209)	.0015 (.159)	-.0047 (-.022)	-.0005 (-.031)	-.0087 (-.056)	.0026

[a]Final form margin estimate.

[b]Flexibility derived at the means.

insignificant at the structural level and, thus, is insignificant in the margin analysis.

Both margins were found to be inversely related to beginning stocks ($BSFF_t$), own-size imports ($I21_t$), total other-size landings (OL_t), and own-size landings ($L21_t$). A one million pound increase in beginning stocks was found to decrease M^{wr} and M^{wp} by .94 and .20 cents, respectively. In terms of margin flexibilities, a one percent increase in beginning stocks will decrease M^{wr} and M^{wp} by .36 and .21 percent, respectively. A one million pound increase in own-size imports was shown to decrease M^{rw} and M^{wp} by 2.09 and .47 cents, respectively. These estimates correspond to M^{rw} and M^{wp} flexibilities of -.035 and -.022 percent. A one million pound increase in own-size landings decreased M^{rw} and M^{wp} by 12.6 and .87 cents, respectively. The corresponding flexibilities for M^{rw} and M^{wp} are -.293 and -.056 percent, respectively. Changes in other-size landings had an inverse relationship with the margins, though the impact was less than for changes in the other quantity variables.

Both margins were found to be positively related to changes in marketing costs. As $TMCI_t$ changes by one unit, M^{rw} and M^{wp} change by 1.06 and .26 cents, respectively, in the same direction. The 21-25 size class margins were found to be more sensitive to changes in the intermediate marketing costs than were the 31-40 size class margins. Since both size classes of shrimp are being analyzed as being raw-headless, the observed disparity in sensitivity to changes in intermediate marketing costs is not due to differing product form. The response differences are more likely due to the larger shrimp being held in inventory longer and incurring increased storage costs, which are embodied in the $TMCI_t$ parameter.

CHAPTER VII
SUMMARY AND CONCLUSIONS

The domestic shrimp industry is the most valuable commercial fishing industry in the United States. Domestic production, however, represents less than half of the domestic consumption of shrimp products over the last two decades. More recently, imports have represented over 70 percent of the market. Though prices have generally trended up over the last ten years, producers of shrimp products have been experiencing economic hard times brought on by fluctuating prices, increased costs of production, over capitalization, and fully exploited stocks. In addition, retailers, wholesalers, and processors have had to endure increased costs of labor, energy, and cost of holding inventories, as well as periods of general economic recession. In an attempt to counter these undesirable market conditions, policy makers have suggested price oriented measures such as market promotion, import control, and increased producer market coordination as means by which to stabilize and boost prices.

To fully understand the impact such policy measures will have on price at each market level, an understanding of the dynamics of prices in the shrimp market system is crucial. Previous research on the domestic shrimp market system has failed to focus on important aspects of price dynamics, particularly the direction of price determination, the nature of lead/lag relationships and the determinants of prices and margins at various market levels on a size class basis. The purpose of

the present study was to fill this void in the basic understanding of how prices and price spreads by size class of shrimp behave across market levels.

Analysis of Price Determination

Causality and Asymmetry Analysis

Unidirectional causality in the absence of feedback such that ex-vessel causes wholesale price and wholesale causes retail price generally characterized the monthly data. An exception to this was the relationship between ex-vessel and wholesale price for the 21-25 size class. These findings suggest monthly price determination was unidirectional from ex-vessel to wholesale price and wholesale to retail price. Unidirectional causality was not found to characterize quarterly prices for either size class. The ama;usos found that quarterly ex-vessel, wholesale, and retail prices are instantaneously related only.

The impulse response functions of the monthly and quarterly price data suggested that the 21-25 size class prices are characterized by a slower adjustment process than the 31-40 size class, with respect to price changes at adjacent market levels. In addition, on a monthly basis the retail/wholesale relationship for both size classes requires more time to adjust.

Asymmetry was found not to characterize the retail/wholesale price and wholesale/ex-vessel price relationships. Price movements between market levels appear to be passed equally regardless of whether causal prices are rising or falling.

The findings of the causality and asymmetry analysis indicate that neither monthly nor quarterly price determination is dominated by the

wholesale market level—a finding contrary to some industry allegations. The wholesale market level is more concentrated relative to the retail and producer level (Hu, 1983). In this sense, the wholesale market level is suspected to have acquired some power over buying and selling functions and thereby may be exercising some control over the pricing process. Acting as a price leader, wholesaler-processors may be able to pass costs up via higher selling prices and pass costs down via lower buying prices. In this capacity, the wholesaler-processor market level would be acting as a causal node in the market place with the other market levels in a lag position. Dominance by the wholesale level in pricing is in general rejected given the upward and symmetric nature of monthly price determination and the simultaneous nature of quarterly price determination.

Though monthly prices are characterized as upward recursive from the producer level, caution must be taken not to immediately suspect that the producer (ex-vessel) level has omnipotent control over short run price determination. On the contrary, vessel operators are in general price takers with few market outlet alternatives for a highly perishable product. This is particularly true when considering that producer cooperatives are the exception rather than the rule. In addition, other forms of market cooperation (market orders, agreements, etc.) are virtually non-existent in the shrimp industry. Rather, the effects of monthly supply shifts, which originate at the producer level and are closely linked to shifts in the environmental conditions, tend to dominate the primary and derived demand shifts which originate at the upper market levels. Possibly, initial buyers of raw product are acting on expectations of how the upper market levels will be reacting, thereby

establishing a lead position at the producer level. In addition, the sampling interval may not be long enough for primary demand shifters to exhibit a significant impact at lower market levels. This appears to be particularly true on a monthly basis. The sampling interval of the quarterly data appears to be long enough for price determination to become less recursive and more interdependent in nature. Over quarters, no one market level appears to dominate the price determination process. This may be due to primary demand shifters having enough time within a quarter to enter into the decision making processes at lower market levels.

Factors of Price Determination

The quarterly expressions for retail, wholesale, and ex-vessel prices for both size classes were estimated using three-stage least squares. Monthly expressions were estimated using ordinary least squares. Given the findings from the causality analysis on quarterly and monthly data, the price expressions were specified as simultaneous and recursive, respectively, in price for both size classes.

Price linkages between wholesale and ex-vessel market levels were found to be stronger than between retail and wholesale market levels, as indicated by the derived elasticities of price transmission. Ex-vessel (wholesale) price is a very important determinant of wholesale (ex-vessel) price, whereas wholesale price was a less important determinant of retail price. The retail market, thus, appears to be more of an isolated market. Wholesalers and producers appear to be very much interdependent and closely linked when formulating price at the respective market levels.

Monthly prices at the retail, wholesale, and ex-vessel market levels appear to be closely related to factors which affect own-market level price in the previous period. Quarterly prices for either size class do not consistently exhibit this characteristic. Quarterly prices also have a shorter lag structure on causal price than monthly prices. On a size class basis, quarterly prices for the larger shrimp require a longer lag structure on causal price than do quarterly prices for the smaller shrimp. These findings on a size class basis are consistent with the monthly price models. The indicated lag structures suggest that monthly and quarterly prices for the larger size shrimp require at least one additional time period for current market information to be incorporated into the price making process. The slower adjustment in prices suggests the larger shrimp are being held in inventory longer, with the smaller more versatile shrimp being pushed to the retail market in a shorter period of time.

Real disposable income was found to not be a significant determinant of monthly or quarterly prices for either size class. This finding reflects the fact that real disposable income changes very little on a monthly or quarterly basis over the time period of the analysis. Previous monthly and quarterly analyses corroborate the insignificance of income while studies using annual data typically find income as significant. The price index for competing meat products was found to have greater effect on quarterly prices for the smaller size class, suggesting a greater degree of substitutability between the smaller shrimp and other meats than for the larger shrimp. Monthly estimates indicated little difference by size class.

In general, total supplies, beginning inventories, imports and landings of raw-headless shrimp had the anticipated negative relationship with the respective price. An exception to this general finding was the positive estimate for imports of all other sizes of shrimp. Total supply of raw-headless shrimp on the retail market was found to negatively impact prices for both size classes, with a larger impact on the 21-25 size class. This was found to be true for the monthly and quarterly estimates and the derived price flexibilities. In the absence of significant cross effects, the inverse of the price flexibility estimate represents the lower limit of the price elasticity. Therefore, demand for the 21-25 size class shrimp appears to be more inelastic than for the smaller 31-40 size count shrimp, which suggests that the smaller shrimp substitutes with other size classes more easily. This conclusion, plus the greater substitutability of small shrimp with other meat products, suggests a more isolated market for the larger shrimp.

Beginning inventories were found to have a negative impact on both size classes, but a much larger unit and percentage impact on the prices for the smaller shrimp. This suggests that as inventories increase, prices of the smaller shrimp vary more, possibly through increased promotional efforts to clear out unwanted stocks of small shrimp. As was indicated in the monthly analysis for retail price, the smaller shrimp appear to be a greater competitor with other meats for a share of the consumer's budget than are the larger shrimp. Therefore, wholesalers may be more willing to adjust prices for the smaller shrimp to reduce inventories during periods when stocks are building. This finding, coupled with the indicated shorter lag structure on the 31-40 size class, suggests that wholesalers attempt to move the smaller shrimp

through the market at a faster pace than the larger shrimp. If smaller shrimp are perceived as less of a luxury item than larger shrimp, wholesalers may be more able to market these smaller shrimp in food stores on a larger scale than they could larger shrimp.

Imports of own-size shrimp were found to have a negative impact on prices for both size classes, however, the impact is much larger for the smaller size shrimp. The average volume of classified shrimp imports from 1972 through 1982 in the 31-40 size class is 30 percent greater than the amount imported for the 21-25 size class. However, on a relative basis imports are more important to the 21-25 size class. Over the same period an average 42 percent of the supply of 21-25 size class raw-headless shrimp was imported, while only 36 percent of the supply of 31-40 size class shrimp was imported. This relationship may be particularly important in the future since much of the shrimp produced in mariculture systems will be in the 31-40 size class. Imports of all other size classes of shrimp had a positive relationship with price for both size classes, illustrating how demand and supply of imported product have simultaneously increased over the period of the analysis. To separate these effects, simultaneous estimation of both demand and supply functions is necessary, however, sufficient data for proper specification by size class are not available.

Landings of own-size shrimp had a larger impact on prices of the smaller size class of shrimp, both in terms of unit and percent changes. Thus, prices for the smaller size shrimp are much more sensitive to changes in own-size landings. This finding has particular relevance when considering the impact of policy measures which seek to alter the size distribution of shrimp taken (Texas Closure). Total landings of

all other size classes appear to have essentially the same impact on both size classes.

The marketing cost index was found to have a positive impact on quarterly prices at the retail, wholesale and ex-vessel level for each size class. The monthly analysis found a positive impact at the wholesale level and a negative impact at the ex-vessel level. This discrepancy probably results from this index being a relatively poor representation of processing and marketing costs for this classification of seafood (raw-headless shrimp). The impact of changes in the marketing cost index on the 21-25 size class was much larger than for the 31-40 size class, again suggesting that the larger shrimp are held in inventory longer, thereby incurring increased interest and other holding costs.

Margin Analysis

Marketing margins were derived from the final form estimates as the retail/wholesale (M^{rw}) and wholesale/ex-vessel (M^{wp}) price spreads for each size class. Margins were inversely related to changes in quantity variables, with the exception of imports of all other size classes. These findings suggested possible economies of size in handling quantities of shrimp. The M^{rw} was found to be much more flexibile to changes in quantities than was M^{wp} because retail and wholesale prices are not as closely related as was the wholesale and ex-vessel prices. Both margins for each size class were found to be especially sensitive to change in own-size landings and imports. Changes in marketing costs had a greater impact on both margins for the 21-25 size class product, with a larger impact on the retail/wholesale margin. Total supply of shrimp

on the retail market had, in general, an inverse relationship with both margins. However, changes in total retail supply had a small positive relationship with M^{rw} for the 31-40 size class. Due to questionable results for real disposable income and the index of prices for competing meat products at the structural and final form stages of the analysis, these parameters are interpreted as to have little impact on margins over quarterly intervals.

Methodological Conclusions

The study provided some insight on methodological concerns regarding the appropriate specification of price dependent demands for raw-headless shrimp on a monthly and quarterly basis. These findings on direction and factors of price determination should provide some guidance for specifying models of additional size classes and for different product forms when the data become available.

The findings of the monthly tests in general suggest an upward recursive relationship between prices at the three market levels. Thus, an appropriate specification for prices of both size classes would be such that wholesale and retail prices are some distributed lag function of ex-vessel and wholesale prices, respectively. An exception to this is the relationship characterizing the ex-vessel and wholesale prices for the larger size class. These prices appear to be simultaneously related. The findings of the causality tests on quarterly prices at the three market levels also indicated an interdependent or simultaneous specification would be most appropriate.

The inclusion of lagged own price was also found to be important, even in a simultaneous setting. The tests for asymmetry indicated that

price dependent demands should be specified in symmetric form—at least on a monthly basis.

Income was found not to be a significant determinant of price on a monthly or quarterly basis. Thus, the use of price dependent demands using monthly or quarterly data to address income related issues in the market for a given product form and size class of shrimp (particularly those analyzed in this study) may not be appropriate.

Total imports were found to be positively related to price. Therefore, addressing questions concerning the aggregate import market with recursive or simultaneous price models only is not appropriate. A morecomplete model of supply and demand appears necessary.

Policy Implications

One of the primary purposes of this study was to evaluate the differential impacts of variables of concern on price at each market level. Prior knowledge of these differential impacts is necessary for the prediction of changes in a given price to a change in a specific variable. This information is also vital to understanding changes in price given a policy change which may indirectly effect the market at more than one level.

The estimated price relationships suggest all market levels are impacted by changes in policy measures. Impacts are nearly equal at the wholesale and ex-vessel levels with considerably higher impacts at the retail levels. Impacts at the retail market levels will likely take longer to be fully realized.

No one market level appears to have sufficient market power to acquire an unequal share of the costs and benefits of increased or

reduced trade. On a month to month basis, it appears that one market level will lead another in determining prices. This probably is due to factors other than market power, such as wide month-to-month variations in landings, response time and time required for market information to fully permeate the system. The latter criteria is suggested by the recursive nature of monthly price changes compared to the simultaneous nature of quarterly price movements. Although prices are simultaneously determined on a quarterly basis, price increases from restrictive trade policies can be passed on to higher market levels with proportionately larger price increases. This is particularly true for the larger shrimp. The symmetric nature of price changes found in the analysis suggests price increases resulting form decreased imports will be substantially larger at higher market levels. In addition, given the weaker linkage between retail and wholesale prices than is found between wholesale and ex-vessel prices for both size classes, policy measures administered at the retail level (market promotional programs) may have less of an impact on the total system than will policy measures administered at the lower market levels, such as implementation of cooperatives or market orders.

Although the direction of price impacts are generally the same for the two size classes analyzed, there are some differences in terms of the magnitude of the effects. The 31-40 count shrimp market appears to be much more affected by changes in imports. This is particularly troublesome considering that this market is already subject to wider price responses than the 21-25 count shrimp market for comparable changes in quantities in the domestic market. The 31-40 count shrimp market will most likely be disproportionately impacted by new mariculture production which is expected to produce shrimp of similar size.

The differing magnitude of price responses for the 31-40 and 21-25 count shrimp to changes in various causal factors is useful in assessing the market impacts of other policy measures. One such policy measure is the ban on shrimping in the Fisheries Conservation Zone off the coast of Texas during a period in the summer season—otherwise known as the Texas Closure. The goal of the closure is to increase the quantity of large shrimp available for harvest in Texas and surrounding waters by protecting smaller juvenile shrimp early in the season. This is of particular interest to this study in that one of the two size classes most affected by the 1981 Texas Closure was the 31-40 size class (Klima, Baxter, and Patella, 1982). Given that the predominant size count of shrimp caught in Texas and Louisiana waters during the months immediately following the closure are of the 31-40 size class, the market for the 31-40 count shrimp may realize a larger impact due to policy measures, such as the Texas Closure, that alter the size distribution harvested. Public officials may want to reconsider this policy, especially when considering this size class will most likely be affected by imports resulting from expanded shrimp mariculture production.

The analysis has shown that prices at each market level are, in general, inversely related to quantities. Further, the margin analysis indicated an inverse relationship between quantity and margins, with changes in quantity causing prices to change more at upper market levels. Thus, restrictive trade policies would have the effect of decreasing available supplies, increasing prices, and increasing the price spread. The price spread is made up of profit and cost components. Under the assumption that the market is competitive, profits are reduced to only normal rates of return. Changes in the price spread

will then be due to changes in the cost component. Assuming the market for raw-headless shrimp is functioning competitively, the findings in the margin analysis suggests that inefficiencies may arise in the wholesale-processing sector as quantities are reduced; e.g. through an import quota. Therefore, a reduction in imports may be initially beneficial to producers but of questionable short-run benefit to wholesalers and processors. In the longer run, inefficient firms may be eliminated, resulting in a reduction in competition among the remaining more efficient firms. Reduced competition and higher prices may result in a growing profit component.

Suggestions for Future Research

Proper identification of causal direction was vital to this study. Similarly, the analysis of causality using the Granger, Sims and Haugh-Pierce methods was dependent on the stationarity and white noise properties of the time series of interest. Properly filtering these series is a crucial step. However, as Fiege and Pearce (1979) have noted, the causality tests are conditional on the specific ARIMA filters used. As Pindyck and Rubinfeld (1981) point out, using the Box-Jenkins method of identifying the ARIMA filter requires some subjectiveness when deciding on the final specifications. Hsiao (1979) and Bessler and Schrader (1980) point out that the Akaike (1970) autoregressive predictive error criterion, which removes some of this subjectiveness from the estimation of time series filters, may be a better procedure. Utilizing both approaches in future studies would provide a check for robustness in filter estimation. The possibility of utilizing an inappropriate filter is particularly of concern when considering the importance of the filter

in the derivation of impulse response functions which provide exact specification of the distributed lag relationship between the two time series.

The empirical identification of a directional or "causal" relationship is by no means a definitive indication of a cause and effect relationship between two variables. An empirical analysis of causality by itself only allows for inferences regarding lead/lag structures which is simply an additional piece of information regarding model specification. The assessment of a true causal linkage between two variables is a theoretical question and is only supplemented by the empirical analysis. The causal findings of this study should be viewed in this sense.

The analysis could have benefitted from a more representative sample of prices at all three market levels. Retail and wholesale price represented only the Baltimore, Maryland and New York Fulton markets, respectively. Though prices for shrimp of a given product form may differ primarily by transportation cost between spatially separated markets, a more spatially representative sample of price at the retail and wholesale market levels might provide some conclusive findings regarding strength of causality and length of the lag structure connecting prices in adjacent markets.

Retail price is not reported by NMFS for the 31-40 size class. Prices for the 36-42 size were used instead. Similarly, prior to 1980, ex-vessel price is reported by NMFS as a weighted average for domestic landings in the Gulf of Mexico and South Atlantic. For the years 1980 and after, ex-vessel price is a weighted average for landings in the Western Gulf only. This inconsistency in ex-vessel price is noteworthy due to varying methods of establishing dockside price among ports in the

Gulf. Future causality studies would benefit from the use of price series that are definitionally more consistent in terms of representative regions and size class. In addition, studies of causality on a regional basis would provide insight into the relative importance of major ports and major market areas to the price determination process; i.e., lead/lag relationship between prices among major ports and among markets.

The retail market in this study represented the food-store or grocery sales market, which represents only 20 to 30 percent of the total retail sales for shrimp products. The preponderance of shrimp (70 to 80 percent) are consumed in restaurants and other institutional outlets. Thus, the price analysis in this study pertains only to a very restricted segment of the retail market. Unfortunately, data on the institutional price of shrimp are not available.

An obvious extension to the portion of the study concerned with the estimation of price dependent demands would be to consider additional size classes and product forms. An unfortunate overriding constraint is the paucity of published price and quantity data by size class and product form (breaded shrimp, peeled/deveined, etc.), which is particularly noteworthy for quantity data. Monthly price and quantity data documented over a sufficient length of time to do meaningful analyses are restricted to a very few size classes and product forms. Landings data by size class for the Gulf and South Atlantic by size class are available, however, retail supply and beginning inventories by size class are not available. The "unclassified" import category has increased to approximately 50 percent of reported imports, providing for increased unreliability in import data by size class. There also exists

a shortage of quantity data on alternative product forms at retail and wholesale market levels. Inclusion of terms representing these data in the price models would allow more complete analysis of substitution between size classes and product forms. Further studies into the paths that alternative size classes and product forms take from producer or importer to consumer need to be undertaken.

Cost data for processing, wholesaling, and retailing of shrimp products are also scarce. More representative cost data for seafood processing and marketing, particularly disaggregated into individual components (labor, energy, interest, transportation, etc.) are crucial to the further understanding of the behavior of price spreads. Such data on costs may be superior to the intermediate food marketing cost index for general agricultural commodities published by the USDA, which was used in the study.

A further improvement to the model developed in this study of the determinants of prices and margins would be to include quantity imported as endogenous to the model. Including import price explicitly would allow for additional inferences to be made specifically regarding the important import market. With prices and quantity imported both increasing over time, as has been the case in the last decade, a simultaneous model of the import market may be appropriate.

APPENDIX A
DERIVATION OF IMPULSE RESPONSE FUNCTIONS

The terms to be included in the dynamic shock model relating two adjacent market levels are determined by examining the Haugh-Pierce residual cross-correlations for significance. Each term is estimated by solving for the bivariate regression coefficient (λ_i) which is a function of the standard deviation for each residual series and the corresponding residual cross-correlation estimate at lag k. Once the dynamic shock model is estimated, the respective ARIMA filter models are substituted into the expression. The resulting expression is then solved in terms of the "causal" (lagged) price. The resulting equation is referred to as the impulse response function. The following discussion details this procedure for each size class using monthly and quarterly data.

Monthly Data

31-40 Size Class: $W_t = f(P_t)$

The implied dynamic shock model for the wholesale (W_t)/ex-vessel (P_t) price relationship is given as

(1) $$w_t = (\lambda_0 - \lambda_1 B)e_t + \phi(B)a_t$$

where w_t and e_t are the residual series for wholesale and ex-vessel price, respectively, λ_i are the regression parameters to be estimated, $\phi(B)$ is a polynomial in the lag operator B (which is unique to the white noise disturbance associated with the dynamic shock model), and a_t is

the white noise disturbance associated with the dynamic shock model.

The parameters to be estimated are given as

$$\lambda_0 = \frac{\sigma_w}{\sigma_e}\,[\hat{r}_{we}(0)]$$

$$\lambda_1 = \frac{\sigma_w}{\sigma_e}\,[\hat{r}_{we}(1)]$$

where σ_w and σ_e are the standard deviations of the residual series for wholesale and ex-vessel (lagged) price, respectively, and $\hat{r}_{we}(k)$ is the estimated residual cross-correlation at lag k, where ex-vessel price is the lagged price. Solving for each λ_i gives

(2.1) $\lambda_0 = \frac{.129}{.149}(.752) = .651$

(2.2) $\lambda_1 = \frac{.129}{.149}(.291) = .252$

Therefore, the dynamic shock model is given as

(3) $w_t = (.651 - .252\ B)e_t + \phi(B)a_t$

Replacing w_t and e_t with the respective ARIMA filter models yields

(4) $(1 - B)(1 - .466B + .0928B^2)w_t = (.651 - .252B)(1 - B)(1 - .3896B$
$+ .1335B^3)P_t + \phi(B)a_t$

Performing the necessary operations to solve for w_t in terms of P_t and then simplifying yields

$$w_t = (.651 - .203B - .058B^2 + .078B^3 + .006B^4 - .006B^5 - .005B^6 - .003B^7 - .002B^8 - .001B^9)P_t + \phi'(B)a_t$$

where ϕ' is the polynomial in the lag operator B resulting from the solution process. Writing this in a more parsimonious form by dropping all terms which are small relative to the leading parameters (less than .1) yields

(5) $W_t = (.651 - .203B)P_t + \phi'(B)a_t$

Hereafter, only expressions (1) through (5) are given for the remaining price relationships.

<u>31-40 Size Class: $R_t = F(W_t)$</u>

(1) $r_t = (\lambda_0 - \lambda_1 B - \beta_4 B^4)w_t + \phi(B)a_t$

where r_t is the residual series for retail price.

(2.1) $\lambda_0 = \frac{.172}{.129}(.186) = .246$

(2.2) $\lambda_1 = \frac{.172}{.129}(.360) = .476$

(2.3) $\lambda_4 = \frac{.172}{.129}(.175) = .232$

(3) $r_t = (.246 - .476B - .232B^r)w_t - \phi(B)a_t$

(4) $(1 - B)(1 - .3517B - .2759B^8 + .2346B^9)R_t = (.246 - .476B - .232B^4)(1 - B)(1 - .466B + .0928B^2)w_t + \phi(B)a_t$

(5) $R_t = (.246 - .504B - .240B^4)W_t + \phi'(B)a_t$

<u>21-25 Size Class: $R_t = f(W_t)$</u>

(1) $r_t = (\lambda_0 - \lambda_1 B - \lambda_2 B^2 - \lambda_3 B^3)w_t + \phi(B)a_t$

(2.1) $\lambda_0 = \frac{.215}{.216}(.100) = .099$

(2.2) $\lambda_1 = \frac{.215}{.216}(.227) = .226$

(2.3) $\lambda_2 = \frac{.215}{.216}(.389) = .388$

(2.4) $\lambda_3 = \frac{.215}{.216}(.129) = .128$

(3) $r_t = (.099 - .226B - .388B^2 - .128B^3)w_t + \phi(B)a_t$

(4) $(1 - B)(1 - .1944B)R_t = (.099 - .226B - .388B^2$

$- .129B^3)(1 - B)(1 - .2809B + .1127B^3)W_t + \phi(B)a_t$

(5) $R_t = (.099 - .235B) - .371B^2)W_t + \phi'(B)a_t$

(The following discussion details the impulse response functions derived for the ex-vessel/wholesale price relationship for the 21-25 size class which were derived for $W_t = f(P_t)$ and $P_t = f(W_t)$, due to indications of simultaneity in the causality studies.)

21-25 Size Class: $W = f(P_t)$

(1) $w_t = (\lambda_0 - \lambda_1 B)e_t + \phi(B)a_t$

(2.1) $\lambda_0 = \frac{.217}{.205}(.836) = .885$

(2.2) $\lambda_1 = \frac{.217}{.205}(.167) = .177$

(3) $w_t = (.885 - .177B)e_t + \phi(B)a_t$

(4) $(1 - B)(1 - .2809B + .1127B^3)W_t = (.885 - .117B)(1 - B)(1$

$- .2391B + .0979B^3 + .1145B^5)P_t + \phi'(B)a_t$

(5) $W_t = (.885 - .140B + .099B^5)P_t + \phi'(B)a_t$

21-25 Size Class: $P_t = f(W_t)$

(1) $e_t = (\lambda_0)w_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.205}{.217}(.836) = .789$

(3) $e_t = (.789)w_t + \phi(B)a_t$

(4) $(1 - B)(1 - .239B + .098B^3 + .115B^5)P_t =$

$(.789)(1 - B)(1 - .2809B + .1127B^3)W_t + \phi(B)a_t$

(5) $P_t = (.789)W_t + \phi'(B)a_t$

Quarterly Data

31-40 Size Class: $W_t = f(P_t)$

(1) $w_t = \lambda_0 e_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.279}{.305}(.912) = .834$

(3) $w_t = (.834)e_t + \phi(B)a_t$

(4) $(1 - B)(1 - .1649B) + .3444B^6)W_t =$

$(.834)(1 - B)(1 - .1607B^3 + .4090B^6)P_t + \phi(B)a_t$

(5) $W_t = (.834 - .250B^3 - .141B^4 - .123B^5)P_t + \phi'(B)a_t$

31-40 Size Class: $P_t = f(W_t)$

(1) $e_t = \lambda_0 w_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.305}{.279}(.912) = .998$

(3) $e_t = (.998)w_t + \phi(B)a_t$

(4) $(1 - B)(1 - .1607B^3 + .409B^6)P_t =$

$(.998)(1 - B)(1 - .1649B + .3444B^6)W_t + \phi(B)a_t$

(5) $P_t = (.998 - .165B)W_t + \phi'(B)a_t$

31-40 Size Class: $R_t = f(W_t)$

(1) $r_t = (\lambda_0 + \lambda_1 B)w_t + \phi(B)a_t$

(2.1) $\lambda_0 = \frac{.341}{.279}(.618) = .757$

(2.2) $\lambda_1 = \frac{.341}{.279}(.248) = .304$

(3) $r_t = (.757 + .304B)w_t + \phi(B)a_t$

(4) $(1 - B)(1 - .4172B)R_t = (.757 - .304B)(1 - B)(1 - .1649B$

$+ .3444B^6)W_t + \phi(B)a_t$

(5) $R_t = (.757 - .113B + .263B^6)W_t + \phi'(B)a_t$

31-40 Size Class: $W_t = f(R_t)$

(1) $w_t = (\lambda_0)r_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.279}{.341}(.618) = .505$

(3) $w_t = (.505)r_t + \phi(B)a_t$

(4) $(1 - B)(1 - .1649B + .3444B^6)w_t =$

$(.505)(1 - B)(1 - .4172B) + \phi(B)a_t$

(5) $w_t = (.505 - .128B)r_t + \phi'(B)a_t$

21-25 Size Class: $W = f(P_t)$

(1) $w_t = (\lambda_0 - \lambda_1 B - \lambda_2 B^2)e_t + \phi(B)a_t$

(2.1) $\lambda_0 = \frac{.3845}{.3486}(.934) = 1.030$

(2.2) $\lambda_1 = \frac{.3845}{.3486}(.152) = .168$

(2.3) $\lambda_2 = \frac{.3845}{.3486}(-.186) = -.205$

(3) $w_t = (1.03 - .168B + .205B^2)e_t + \phi(B)a_t$

(4) $(1 - B)(1 + .259B^4 + .334B^6)W_t + (1.03 - .168B$

$+ .205B^2)(1 - B)(1 + .169B^2 + .203B^4 + .425B^6)P_t + \phi(B)a_t$

(5) $W_t = (1.03 - .141B + .406B^2 + .113B^7)P_t + \phi'(B)a_t$

<u>21-25 Size Class: $P_t = f(W_t)$</u>

(1) $e_t = (\lambda_0)w_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.3486}{.3845}(.934) = .847$

(3) $e_t = (.847)w_t + \phi(B)a_t$

(4) $(1 - B)(1 + .169B^2 + .203B^4 + .425B^6)P_t =$

$(.847)(1 - B)(1 + .259B^4 + .334B^6)W_t + \phi(B)a_t$

(5) $P_t = (.847 - .143B^2)W_t + \phi(B)a_t$

<u>21-25 Size Class: $R_t = f(W_t)$</u>

(1) $r_t = (\lambda_0)w_t + \phi(B)a_t$

(2) $\lambda_0 = \frac{.3222}{.3845}(.469) = .393$

(3) $r_t = (.393)w_t + \phi(B)a_t$

(4) $(1 - B)(1 - .460B + .154B^5)R_t = (.393)(1 - B)(1 + .259B^4$

$+ .334B^6)W_t + \phi(B)a_t$

(5) $R_t = (.393 + .181B + .119B^4)W_t + \phi'(B)a_t$

<u>21-25 Size Class: $W_t = f(R_t)$</u>

(1) $w_t = (\lambda_0 + \lambda_1 B)r_t + \phi(B)a_t$

(2.1) $\frac{.3845}{.3222}(.469) = .560$

(2.2) $\frac{.3845}{.3222}(.208) = .248$

(3) $e_t = (.560 - .248B)r_t + \phi(B)a_t$

(4) $(1 - B)(1 + .2594B^4 + .3342B^6)W_t =$

$$(.560 - .248B)(1 - B)(1 - .4596B + .1539B^5)R_t + \phi(B)a_t$$

(5) $W_t = (.560 - .506B + .114B^2)R_t + \phi'(B)a_t$

APPENDIX B
FINAL MODEL SPECIFICATIONS

The final specification of each model estimated is given in Chapter VI. The non-price predetermined variables included in the final specification of each model are as discussed in Chapter IV. The prices (current and/or lagged) which are found in the M_j set of each price model, however, were selected initially via the impulse response models and statistical criteria. The models were initially estimated with the full complement of current and/or lagged prices, as suggested by the impulse response functions. Due to insignificance (monthly and quarterly models) and difficulties encountered in obtaining final form estimates (quarterly models) for lags greater than two, certain prices were omitted from the final monthly and quarterly models estimated and presented in Chapter VI. Thus, a form of pretesting was employed to arrive at the M_j price set for each model.

Once the price models were specified, initial estimates were performed to check for serial correlation in the residuals. The total and partial autocorrelation functions of each model were examined. In addition, the null hypothesis of no serial dependence (white noise) was tested for the residual series of each model using the Ljung and Box (1978) statistic given as

$$\chi^2 = \frac{n(n+2)\sum_{k=1}^{m} r_k}{n-k}$$

where

$$r_k = \frac{\sum_{k=1}^{n-k} a_t a_{t-k}}{\sum_{k=1}^{n} a_t^2}$$

where n is the number of observations in the series, k is the lag length, m is the maximum lag, and a_t is the residual series. For virtually every series for which the null hypothesis was rejected, first order autocorrelation was evident. Thus, the polynomial $\lambda(B)$ defined in Chapter V is not simply equal to one. A number of methods are available that correct for serial correlation. This study utilized both the Cochran-Orcutt method and addition of a lagged dependent variable. The inclusion of a dependent variable lagged one period, however, gave more promising results, based on the resulting Ljung-Box statistic. The results of the procedure for the monthly and quarterly data for both size classes are given in Table B. Therefore, an additional lagged endogenous price may occur in the M_j of each price model due to statistical considerations.

The efficient estimation of systems of equations (this study employed recursive and simultaneous systems) requires that the cross correlation of error terms must be taken account. In particular, the contemporaneous cross correlation among error terms in a system of models must theoretically be zero. Mehta and Swamy (1976), however, suggest a less rigid criterion, e.g. that the contemporaneous cross correlation between error terms be less than or equal to .30. When this is not the case, single equation methods and 2SLS are no longer efficient. Instead, single equation and 2SLS methods should be replaced by seemingly unrelated estimation and 3SLS methods, respectively (Pindyck

Table B: Ljung-Box Chi-Square Tests for White Noise on the Residuals of the Monthly and Quarterly Retail (R_t), Wholesale (W_t), and Ex-vessel (P_t) Models Before and After Inclusion of a Lagged Dependent Variable.

Dependent variable	31-40 Size Class		21-25 Size Class	
	Monthly			
	B[a]	A[b]	B	A
R	355.04*	24.05***	264.46*	5.22***
W	107.06*	26.04***	NE[c]	NE
P	499.47*	38.26*	NE	NE
	Quarterly			
R	73.70*	21.51***	65.29*	11.61***
W	12.57***	-	38.17*	26.84***
P	21.74***	-	31.02**	-

[a] χ^2_{18} before inclusion of dependent variable lagged one period.

[b] χ^2_{18} after inclusion of dependent variable lagged one period.

[c] Not estimated

*Reject null hypothesis of no dependence at the .01 level

**Reject null hypothesis of no dependence at the .025 level.

***Fail to reject the null hypothesis of no dependence at the .05 level.

and Rubinfeld, 1981). This study found that the monthly models for both size classes exhibited contemporaneous cross correlation of the error terms well within the Mehta and Swamy efficiency range. Thus, single equation methods were appropriate for the monthly models. However, the contemporaneous cross correlation among error terms for the quarterly simultaneous models was found to exceed the .30 value for both size classes. Therefore, the quarterly models were estimated with 3SLS methods.

APPENDIX C

GRANGER TESTS USING DATA FILTERED BY USING ARIMA MODELS

Table C.1: Granger Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 31-40 Size Class Using Data Filtered by an ARIMA Model.

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

° Unidirectional Test: $F_{12,121} = 1.57$**

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

° Unidirectional Test: $F_{12,121} = 3.65$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

° Unidirectional Test: $F_{12,121} = 0.96$**

D. NULL HYPOTHESIS: wholesale does not cause retail price

° Unidirectional Test: $F_{12,121} = 3.91$*

*Reject null hypothesis at the .05 level.

**Fail to reject null hypothesis at the .10 level.

Table C.2: Granger Causality Tests on Monthly Ex-vessel, Wholesale, and Retail Prices for the 21-25 Size Class Using Data Filtered by an ARIMA Model.

A. NULL HYPOTHESIS: wholesale does not cause ex-vessel price

- Unidirectional Test: $F_{12,125} = 0.87$**

B. NULL HYPOTHESIS: ex-vessel does not cause wholesale price

- Unidirectional Test: $F_{12,125} = 2.41$*

C. NULL HYPOTHESIS: retail does not cause wholesale price

- Unidirectional Test: $F_{12,125} = 1.14$**

D. NULL HYPOTHESIS: wholesale does not cause retail price

- Unidirectional Test: $F_{12,125} = 3.27$*

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*Reject null hypothesis at the .05 level.

**Fail to reject null hypothesis at the .10 level.

Table C.3: Granger Causality Tests on Quarterly Wholesale and Retail Prices for the 21-25 Size Class Using Data Filtered by an ARIMA Model.

A. NULL HYPOTHESIS: retail does not cause wholesale price

- Unidirectional Test: $F_{6,14} = 1.18$**

B. NULL HYPOTHESIS: wholesale does not cause retail price

- Unidirectional Test: $F_{6,14} = 0.65$**

*Fail to reject null hypothesis at the .10 level.

APPENDIX D
REDUCED FORM ESTIMATES

Table D.1: Reduced Form Estimates and Flexibilities for Quarterly price Models at the Retail (R_t), Wholesale (W_t), and Ex-vessel (P_t) Market Levels for the 31–40 Size Class.

Endogenous Variables	Predetermined Variables									
	R_{t-1}	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I31_t$	OL_t	$L31_t$	$TMCI_t$
R_t	.848[a] (.836)[b]	.00059 (.132)	−.00057 (−.012)	−.0023	−.0269 (−.379)	.0032 (.045)	−.0882 (−.071)	−.0027 (−.021)	−.0734 (−.104)	.0013
W_t	.393 (.552)	.00539 (1.724)	−.00516 (−.151)	−.0211	−.0485 (−.973)	.0057 (.114)	−.1586 (−.181)	−.0048 (−.054)	−.1321 (−.266)	.0023
P_t	.356 (.596)	.00489 (1.864)	−.00468 (−.164)	−.0191	−.0439 (−1.050)	.0052 (.124)	−.1437 (−.195)	−.0045 (−.060)	−.1223 (−.294)	.0018

[a]Reduced form estimates.

[b]Flexibility estimates derived at the means.

Table D.2: Reduced Form Estimates and Flexibilities for Quarterly Price Models at the Retail (R_t), Wholesale (W_t), and Ex-vessel (P_t) Market Levels for the 21-25 Size Class.

Endogenous Variables	Predetermined Variables										
	R_{t-1}	W_{t-1}	RDY_t	$TCFF_t$	CPI_t	$BSFF_t$	OI_t	$I31_t$	OL_t	$L31_t$	$TMCI_t$
R_t	.548[a] (.541)[b]	.487 (.342)	-.00081 (-.142)	-.0078 (-.126)	.0044	-.0037 (-.041)	.0027 (.030)	-.0083 (-.004)	-.0029 (-.019)	-.0500 (-.033)	.0042
W_t	-.335 (-.467)	1.020 (1.012)	-.00092 (-.228)	-.0090 (-.204)	.0050	-.0077 (-.120)	.0056 (.088)	-.0175 (-.012)	-.0061 (-.057)	-.1048 (-.099)	.0088
P_t	-.288 (-.471)	.878 (1.023)	-.00079 (-.230)	-.0077 (-.205)	.0043	-.0066 (-.120)	.0048 (.089)	-.0150 (-.012)	-.0064 (-.070)	-.1091 (-.121)	.0073

[a]Reduced form estimates.

[b]Flexibility estimates derived at the means.

REFERENCES

Akaike, H. "Autoregressive Model Fitting for Control." Annals of the Institute of Statistical Mathematics 22(1970):163-180.

Allen, R.G.D. Mathematics Analysis for Economists. London: Macmillan and Co., 1938.

Anderson, R.G., J.M. Johannes, and R.H. Rosche. "A New Look at the Relationship Between Time-Series and Econometric Models." Journal of Econometrics 23(1983):235-252.

Bain, J.S. Industrial Organization. New York: John Wiley and Sons, 1964.

Beck, R.L., and L.L. Mather. "Price-Margin Movements in the Fluid Milk Industry." Southern Journal of Agricultural Economics 8(1976):133-137.

Bessler, D.A., and L.F. Schrader. "Relationship Between Two Price Quotes for Eggs." American Journal of Agricultural Economics 62(1980a):766-771.

Bessler, D.A., and L.F. Schrader. "Measuring Leads and Lags Among Prices: Turkey Products." Agricultural Economics Research 32(1980b):1-7.

Bishop, R.V. "The Construction and Use of Causality Tests." Agricultural Economics Research 31(1979):1-6.

Bockstael, N. A Market Model for New England Groundfish Industry. Agricultural Experiment Station Bulletin No. 422. Department of Resource Economics, University of Rhode Island, July 1977.

Bockstael, N.E. "Disequilibrium and Seafood Trade Modelling." Proceedings of the International Seafood Trade Conference, University of Alaska, Alaska Sea Grant Report No. 83-2. 1982.

Box, G.E.P., and G.M. Jenkins. Time Series Analysis--Forecasting and Control. San Francisco: Holden-Day, 1976.

Box, G.E.P., and D.A. Pierce. "Distribution of Residual Auto-correlations in Autoregressive Integrated Moving Average Time Series Models." Journal of the American Statistical Association 65(1970):1509-1526.

Bressler, R.G., and R.A. King. Markets, Prices, and Interregional Trade. Raleigh, N.C.: John Wiley and Sons, 1978.

Brorsen, B.W. "A Study of the Efficiency and Dynamics of Rice Prices. Ph.d. dissertation, Texas A&M University, May 1983.

Chiang, A.C. Fundamental Methods of Mathematical Economics. New York: McGraw-Hill, 1974.

Christ, C.F. Econometric Models and Methods. New York: John Wiley and Sons, 1966.

Chui, M.K. "Ex-vessel Demand by Size for the Gulf Shrimp." M.S. thesis, Texas A&M University, 1980.

Cleary, D. "Demand and Prices of Shrimp." Division of Economic Research, Working Paper No. 15. Washington, D.C., 1969.

Cochrane, W.W. "The Market as a Unit of Inquiry in Agricultural Economic Research." Journal of Farm Economics 37(1957):21-39.

Colclough, W.G., and M.D. Lange. "Empirical Evidence of Causality From Consumer to Wholesale Prices." Journal of Econometrics 19(1982):379-384.

Deaton, A., and J. Muellbauer. Economics and Consumer Behavior. Cambridge: Cambridge University Press, 1980.

Dahl, D.C., and J.W. Hammond. Market and Price Analysis--The Agricultural Industries. New York: McGraw-Hill, 1977.

Dalrymple, D.G. On the Nature of Marketing Margins. Department of Agricultural Economics Report No. 824. Michigan State University, April 1961.

Doll, J.P. "An Econometric Analysis of Shrimp Ex-vessel Prices, 1950-1968." American Journal of Agricultural Economics 54(1972):431-440.

Ethridge, M.D. "A Comparative Regional Analysis of the Wholesale Marketing Margin for Crushed Cottonseed." Southern Journal of Agricultural Economics 9(1975):185-196.

Feige, E.L., and D.K. Pearce. "The Casual Causal Relationship Between Money and Income: Some Caveats for Time Series Analysis." Review of Economics and Statistics 61(1979):521-533.

Fisher, B.S. "The Impact of Changing Marketing Margins on Farm Prices." American Journal of Agricultural Economics 63(1981):261-263.

Friedman, M. Price Theory: A Provisional Text. New York: Aldine Publishing Co., 1962.

Fuller, T.S.A. An Introduction to Time Series Analysis. New York: John Wiley and Sons, 1976.

Gardner, B.C. "The Farm-Retail Price Spread in a Competitive Food Industry." American Journal of Agricultural Economics 57(1975):399-409.

George, P.S., and G.A. King. Consumer Demand for Food Commodities in the United States with Projections for 1980. Giannini Foundation Monograph No. 26. California Agricultural Experiment Station, University of California, Berkeley, March 1971.

Gillespie, W.C., J.L. Hite, and J.S. Lytle. An Econometric Analysis of the Shrimp Industry. Economics of Marine Resources Report No. 2. South Carolina Agricultural Experiment Station, 1969.

Goldberger, A.S. Econometric Theory. New York: John Wiley and Sons, 1964.

Gollnick, H. "Zur Statistischen Schatzung und Profung Irreversibler Nachfragefunktionen." Agronwirtschaft 21(1972):227-231.

Gould, J.P., and C.E. Ferguson. Microeconomic Theory. Homewood, Ill.: Richard P. Erwin, 1980.

Granger, C.W.J. "Investigating Causal Relations by Econometric Models and Cross Spectral Methods." Econometrica 37(1969):424-438.

Granger, C.W.J., and P. Newbold. Forecasting Economic Time Series. New York: Academic Press, 1977.

Grant, W.E., and W.L. Griffin. "A Bioeconomic Model of the Gulf of Mexico Shrimp Fishery." Transactions of the American Fisheries Society 108(1979):1-13.

Grant, W.R., A.W. Ngenge, B.W. Brorsen, and J.P. Chavas. "Grain Price Interrelationships." Agricultural Economics Research 35(1983):1-9.

Griffith, G.R. "A Cross-Spectral Approach to Measuring Pricing Efficiency in the New South Wales Pigmeat Market." Review of Marketing and Agricultural Economics 43(1975):163-183.

Gupta, S., and R.A.E. Mueller. "Pricing Efficiency in Markets for Slaughter Hogs in West Germany." Forum--Reports on Current Research in Agricultural Economics and Agribusiness Management No. 1. Department of Agricultural Economics, University of Kiel, 1981.

Haugh, L.D. "The Identification of Time Series Interrelationships with Special Reference to Dynamic Regression." Ph.d. dissertation, University of Wisconsin-Madison, 1972.

Haugh, L.D., and G.E.P. Box. "Identification of Dynamic Regression (Distributed Lag) Models Connecting Two Time Series." Journal of the American Statistical Association 72(1977):121-130.

Heien, D.M. "Markup Pricing in a Dynamic Model of the Food Industry." American Journal of Agricultural Economics 62(1980):10-18.

Henderson, J.M., and R.E. Quandt. Micro Economic Theory. New York: McGraw-Hill, 1980.

Hicks, J.R. The Theory of Wages. Magnolia, Mass.: Peter Smith, 1957.

Hopkins, J.C., J.P. Nichols, and J.W. Richardson. "An Econometric Analysis of the U.S. Shrimp Industry." Unpublished manuscript, Department of Agricultural Economics, Texas A&M University, 1980.

Houck, J.P. "A Look at Flexibilities and Elasticities." Journal of Farm Economics 48(1966):225-232.

Hsaio, C. "Autoregressive Modeling and Causal Ordering of Economic Variables." Journal of Economic Dynamics and Control 4(1982):243-259.

Hu, T.W. "The U.S. Shrimp Industry--An Economic Profile." Unpublished manuscript, Department of Economics, Pennsylvania State University, 1983.

Kmenta, J. Elements of Econometrics. New York: Macmillan and Co., 1971.

Kohls, R.L., and J.N. Uhl. Marketing of Agricultural Products. New York: Macmillan and Co., 1980.

Ljung, G.M., and G.E.P. Box. "On a Measure of Lack of Fit in Time Series Models." Biometrika 65(1978):297-303.

McCallum, J. "Competitive Price Adjustments: An Empirical Study." American Economic Review 64(1974):56-65.

McClements, L.D. "An Analysis of Retail Meat Pricing in Britain." Journal of Applied Economics 4(1972):291-300.

Mehta, J.S., and P.A.V.B. Swamy. "Further Evidence on the Relative Efficiencies of Zellner's Seemingly Unrelated Regression Estimators." Journal of the American Statistical Association 71(1976):634-639.

Miller, S.E. "Lead-Lag Relationships Between Pork Prices at the Retail, Wholesale, and Farm Levels." Southern Journal of Agricultural Economics 12(1980):73-76.

Mock, C.R. "Report on Penaeid Shrimp Culture Consultation and Visit, Guayaquil, Ecuador, South America, and Panama, Central America, August 12 to September 20, 1981." Proceedings of the Thirteenth Annual Meeting of the World Mariculture Society 12(1982):165-186.

Nelson, C.R. Applied Time Series Analysis for Managerial Forecasting. San Francisco: Holden-Day, 1973.

Ngenge, A.W. "A Time Series Analysis of Selected U.S. Farm Commodity Markets." Ph.d. Dissertation, Texas A&M University, 1982.

Nichols, J.P., and L. Johnston. "The Influence of Alternative Pricing Methods on Ex-Vessel Shrimp Prices." Department of Agricultural Economics Staff Paper DIR-79-1 SR-7. Texas A&M University, August 1979.

Office of Technology Assessment. Establishing a 200-Mile Fisheries Zone. U.S. Congress, Washington, D.C., June 1977.

Orcutt, G.H. "Actions, Consequences, and Causal Relations." Review of Economics and Statistics 34(1952):305-313.

Penn, E.S. "Marketing Bill and Its Cost Components of U.S. Food Fish Products." NOAA Technical Memorandum NMFS OF 3. Economic Analysis Staff, Office of Policy and Planning. Washington, D.C., 1980.

Pierce, D.A. "Relationships--and the Lack Thereof--Between Economic Time Series, with Special Reference to Money and Interest Rates." Journal of the American Statistical Association 72(1977):11-26.

Pindyck, R.S., and D.L. Rubinfeld. Econometric Models and Economic Forecasts. New York: McGraw-Hill, 1981.

Popkin, J. "Consumer and Wholesale Prices in a Model of Price Behavior by Stage of Processing." The Review of Economics and Statistics 56(1974):486-501.

Prochaska, F.J. "Prices, Marketing Margins, and Structural Change in the King Mackerel Marketing System." Southern Journal of Agricultural Economics 10(1978):105-109.

Prochaska, F.J. "Processing and Marketing Shrimp Products." Unpublished Manuscript, Food and Resource Economics Department, 1983.

Prochaska, F.J., and J.C. Cato. Economic Conditios in the Gulf of Mexico Shrimp Industry: 1960-1981. Food and Resource Economics Department Staff Paper No. 180. University of Florida, 1981.

Prochaska, F.J., and W.R. Keithly. "The U.S. Shrimp Import Market: Legislation and Impacts on Fishery Managment." National Shellfish Journal (forthcoming).

Rojko, A.S. The Demand and Price Structure for Dairy Products. U.S. Department of Agriculture Technical Bulletin 1168, 1957, pp. 180-181.

Schuler, F.M. "National Sea Grant Activities in Marine Economics." In Current Activities and Research Needs in Marine Economics for the Gulf South Atlantic States. Florida Sea Grant Technical Paper No. 27. University of Florida, pp. 31-36, 1983.

Shepherd, G.S. Marketing Farm Products, Economic Analyses. Ames: Iowa State University Press, 1955.

Shonkwiler, J.S., and T.H. Spreen. "A Dynamic Regression Model of the U.S. Hog Market." Canadian Journal of Agricultural Economics 30(1982):37-40.

Shonkwiler, G.S., and T.H. Spreen. Projecting the Impact of Increasing Energy Costs on the Florida Cattle Industry. Agricultural Experiment Station Bulletin 835. University of Florida, June 1983.

Silberberg, E. The Structure of Economics--A Mathematical Analysis. New York: McGraw-Hill, 1978.

Silver, J.L., and T.D. Wallace. "The Lag Relationship Between Wholesale and Consumer Prices." Journal of Econometrics 12(1980):375-387.

Sims, C.A. "Money, Income, and Causality." American Economic Review 62 (1972):540-542.

Sporleder, T.L., and J.P. Chavas. "Aspects of Pricing Efficiency and the Value of Information." Unpublished working paper, Department of Agricultural Economics, Texas A&M University, 1979.

Spreen, T.H., and J.S. Shonkwiler. "Causal Relationships in the Fed Cattle Market." Southern Journal of Agricultural Economics 13(1981):145-153.

Strotz, R.H., and H. Wold. "Recursive versus Non-Recursive Systems: An Attempt at Synthesis." Econometrica 28(1960):417-427.

Suazo, M.R. "World Shrimp Production and Implications for the United States Import Market," Masters thesis, University of Florida, 1983.

Theil, H. Principles of Econometrics. New York: John Wiley and Sons, 1971.

Thompson, M.E., and K.J. Roberts. Forecasting Ex-Vessel Shrimp Prices for the Northern Gulf. Proceedings of the Seventh Annual Tropical Subtropical Fisheries Technological Conference of the Americas, Texas A&M University Sea Grant TAMU-SG-82-110, 1982.

Thompson, M.E., and K.J. Roberts. "An Econometric Analysis of the U.S. Shrimp Market." Unpublished manuscript, Center for Wetland Resources, Louisiana State University, 1983.

Tomek, W.G., and K.L. Robinson. Agricultural Product Prices. Ithaca, N.Y.: Cornell University Press, 1972.

U.S. Department of Agriculture (USDA). Agricultural Outlook. Various issues, 1975-1981.

U.S. Department of Agriculture (USDA). Food Consumption, Prices, and Expenditures 1962-1982. Economic Research Service, Statistical Bulletin No. 702. 1983.

U.S. Department of Commerce(a), Bureau of Economic Analysis. Business Statistics: 1982. 23rd Edition, 1983.

U.S. Department of Commerce(b), NOAA, NMFS. Fisheries of the United States. Various issues, 1980-1983.

U.S. Department of Commerce(c), NOAA, NMFS. Market News Reports. Various issues, 1981-1983.

U.S. Department of Commerce(d), NOAA, NMFS. Shellfish Market Review--Annual Summary. Various issues, 1968-1982.

U.S. Department of Commerce(e), NOAA, NMFS. Unpublished data files.

U.S. Department of Labor, Bureau of Labor Statistics. CPI Detailed Report. December 1972 through December 1981.

U.S. International Trade Commission (UITC). "Shrimp." Report to the President, Publication No. 773. 1976.

"U.S. Relations with Mexico," Fishing Gazette Magazine. 98(1981):12-13.

van Dijk, G. "Price Formation and Margin Behavior of Meat in the Netherlands and the Federal Republic of Germany." Department of Agricultural Economics, Agricultural University of Wageningen, the Netherlands, 1978.

Ward, R.W. "Asymmetry in Retail, Wholesale, and Shipping Point Pricing for Fresh Vegetables." American Journal of Agricultural Economics 64(1982):205-212.

Watson, D.S. Price Theory and its Uses. Boston: Houghton Mifflin, 1963.

Waugh, F.W. Demand and Price Analysis: Some Examples from Agriculture. HRS, USDA Technical Bulletin No. 1316, 1964.

Young, T. "Modeling Asymmetric Consumer Responses with an Example." Journal of Agricultural Economics 31(1980):175-186.

Zellner, A. "Statistical Analysis of Econometric Methods." Journal of the American Statistical Association 74(1979):628-642.

BIOGRAPHICAL SKETCH

Charles Marcus Adams was born to Odice ("Skeet") and Ophelia Adams on June 1, 1954, in Houston, Texas. He graduated from R.L. Turner High School in Farmers Branch, Texas, in June, 1972. He received the Bachelor of Science degree Cum Laude in wildlife and fisheries science with a fisheries option from Texas A&M University in May, 1976. He also received the Master of Science Degree in agricultural economics from Texas A&M University in December of 1978. From 1978 through 1980, he served as research associate in the Department of Agricultural Economics at Texas A&M University. From 1972 through 1980, his skills as a duck hunter par excellence were honed on the Brazos River bottom.

In September 1980, Chuck entered the Food and Resource Economics Department at the University of Florida to pursue the Ph.D. with an interest in marine economics. He served as graduate research assistant until September, 1984, when he accepted the position of marine economics specialist with the Florida Sea Grant program.

Chuck married the voluptuous former Sherry Annette Densmore, a native of Buffalo, New York, in June, 1979. His permanent address is 5418 S.W. 80th Street, Gainesville, Florida 32608.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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